

Preliminary Reconnaissance Water Quality Survey of the Buffalo National River

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WATER RESOURCES RESEARCH CENTER

Publication No. 19

UNIVERSITY OF ARKANSAS
FAYETTEVILLE

1973

PRELIMINARY RECONNAISSANCE WATER
QUALITY SURVEY OF THE
BUFFALO NATIONAL RIVER

Submitted by:

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on Behalf of

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National Park Service Contract No. CX 70030105

October 10, 1973

ACKNOWLEDGEMENT

The work performed during this contract was supported in part with funds provided by the Office of Water Resources Research, U.S. Department of the Interior; the National Park Service, U.S. Department of the Interior; and the University of Arkansas.

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TABLE OF CONTENTS

<u>SUBJECT</u>	<u>PAGE</u>
Abstract.	1
Introduction.	1
Background Information.	2
Physical Parameters	4
Intensive "One Shot" Survey	16
Geochemical Sediment Analysis	51
Phycological Report	59
Bottom Fauna Description.	65
Vegetation and Site Characteristics	85
Summary	99
Future Research and Monitoring Program.	102
Future Priority Modifications	105
References.	106
Appendices.	108

TABLE OF CONTENTS

<u>SUBJECT</u>	<u>PAGE</u>
Abstract.	1
Introduction.	1
Background Information.	2
Physical Parameters	4
Intensive "One Shot" Survey	16
Geochemical Sediment Analysis	51
Phycological Report	59
Bottom Fauna Description.	65
Vegetation and Site Characteristics	85
Summary	99
Future Research and Monitoring Program.	102
Future Priority Modifications	105
References.	106
Appendices.	108

PRELIMINARY RECONNAISSANCE WATER

QUALITY SURVEY OF THE

BUFFALO NATIONAL RIVER

Abstract

In accordance with Contract No. CX 700030105, dated 12 February 1973, the University of Arkansas, Water Resources Research Center is submitting a "Preliminary Reconnaissance Water Quality Survey of the Buffalo National River." The Water Resources Research Center of Arkansas has supplied the necessary personnel and facilities to perform a preliminary reconnaissance survey of the Buffalo National River of Arkansas with special emphasis placed on the establishment of both permanent and temporary benchmarks for water quality sampling. Preliminary water quality samples have been collected to make those chemical, physical, and biological analyses as defined by Mr. Roland H. Wauer and other Park Service personnel on 3 May 1973.

INTRODUCTION:

Public Law 92-237 established the Buffalo National River in March of 1972. Under this legislation, the National Park Service will acquire most of the land along approximately 132 miles of the stream. As a National River, it is expected that the recreational use of the stream will increase and that the pressures of this increased use of the river will have the potential of altering the water quality within the basin. In order to evaluate water quality changes that may take place due to increased recreational use of the river, it was necessary to establish a baseline for the present water quality of the Buffalo River.

Preliminary Reconnaissance Water Quality Survey Parameters for the Buffalo National River Project were as follows:

- 1) Physical, biological, and chemical properties of the river water to be analyzed at eight selected sample sites (chemical investigation to include trace analysis of water and sediments).
- 2) Qualitative bottom fauna description of accessible sample sites.
- 3) Mapping of plant communities in vicinity of sample sites.

BACKGROUND INFORMATION

The Buffalo River originates in the Springfield Plateau, the middle level of the Ozark Plateaus in Newton County, Arkansas. It flows generally eastward, dissecting the Springfield Plateau as it drops from approximately elevation 2000 feet in the headwaters to around 500 feet at its confluence with White River. Although 132 miles of the Buffalo River will be included in the National River System, an additional 10 to 12 miles of the river can be identified in the Ozark National Forest above the boundary of the lands that will be administered by the Park Service.

Rocks which crop out in the Buffalo River area are of sedimentary origin. They include rocks which belong to the Ordovician, Mississippian, and Pennsylvanian Systems. Units of Silurian and Devonian age are absent as the result of erosion or nondeposition. Ordovician-age strata include the Cotter, Powell, Everton, St. Peter, Plattin, and Fernvale Formations. Overlying Ordovician-age strata are the Boone, Batesville, Fayetteville, and Pitkin Formations of Mississippian-age. Lower Pennsylvanian strata present in the study area include Hale, Bloyd, and Atoka Formations. All of these rocks crop out or underlie much of the Paleozoic area of northern Arkansas.

PHYSICAL, BIOLOGICAL, AND CHEMICAL
PROPERTIES OF THE BUFFALO NATIONAL RIVER

PHYSICAL PARAMETERS

Principal Investigator: Dr. D. G. Parker

Three, two day, sampling trips were taken in order to collect information on water quality. The dates of these trips were May 22-23, June 10-11, and June 24-25.

During each trip eight sampling stations were surveyed. The location of each sampling station is shown on the map, Figure 1. The following is a brief description of the locations of each station:

Station #1: Boxley - located immediately downstream from Highway 21 bridge.

Station #2: Shaddox - located downstream from the confluence with Mill Creek at Shaddox Cemetery.

Station #3: Jasper - located on the Little Buffalo River at Highway 7 bridge.

Station #4: Hasteley - located at the low water bridge upstream from Highway 123 bridge.

Station #5: Gilbert - located at the Gilbert landing.

Station #6: Highway 14 - located just downstream from Highway 14 bridge.

Station #7: State Park - located in Buffalo River State Park in camping area above sewage effluent.

Station #8: Rush - located downstream from influent of Clabber Creek.

Water Quality Data:

Tables 1, 2, and 3 list the pertinent water quality information obtained during the study period. The following is a brief description of each parameter;

Flow - Streamflow was determined at stations #2 and #3 to establish the relative quantity of flow in the Little Buffalo. It appears that the flow in the Little Buffalo makes up approximately 29% of the total flow in the Buffalo River below the confluence. This indicates that any water quality problem in the Little Buffalo could have a significant effect on water quality in the Buffalo.

Temperature - The temperature of the water in the river increased slightly from May through June and is generally cooler upstream than downstream.

Dissolved Oxygen - The dissolved oxygen concentration in the river was consistently above 7.2 mg/l which is sufficient to support a healthy aquatic environment.

pH - The pH varied from 7.0 to 7.9; however, no trend is readily apparent.

Color and Turbidity - The color and turbidity of the river water were generally low; however, it was observed during the first sampling trip that both parameters can be significantly affected by rain water runoff.

Nitrate - Variation in nitrate nitrogen are shown in Figure 2. The concentrations appear to be largest in the downstream stations. This increase could possibly be the result of increased input of agricultural runoff and domestic waste discharges into the river.

Orthophosphate - Variations in orthophosphate are shown in Figure 3. The concentrations of orthophosphates were determined under field conditions and are possibly inaccurate as a result. However, there appears to be a general increase in

concentration downstream. These variations are probably due to the same factors affecting nitrate.

Alkalinity - Variations in alkalinity are shown in Figure 4.

Alkalinity is primarily a measure of the bicarbonate concentration in the water. The alkalinity in the Buffalo River increases in the downstream direction. This increase is probably the result of changing geological conditions as the river drops in elevation.

Hardness - Hardness is a measure of the concentration of divalent metal ions, principally calcium and magnesium. The hardness in the river is similar to the alkalinity and is probably influenced by the same factors that influence alkalinity in this system.

Chlorides - The chloride concentration was low at all stations on the river.

Conductivity - The conductivity of water is primarily influenced by the concentration of dissolved solids in the water. The conductivity of the river increased in the downstream direction and indicates an increase in the dissolved solids concentrations in the lower portion of the river.

Suspended Solids - Suspended solids concentrations in the river are relatively low (< 11 mg/l) except for stations 2, 4, and 5 on May 22-23. This increase was a result of heavy rains which started during May 22.

Total Solids - Total solids increase downstream which is a result of the increase in dissolved solids.

Coliform Organisms - Coliform organisms are indicators of possible fecal contamination in water. The United States Public

Health Service sets a limit of one coliform per 100 ml of water as a safe level for drinking water. Figure 5 shows the variation in total coliforms in the river. Station #3 at Jasper, Arkansas consistently showed high concentrations of organisms and samples collected in Mill Creek above station #2 also showed high coliform counts. The actual sources of this contamination could only be determined by further investigation but there is sufficient evidence to recommend that the Buffalo River water not be used as a source of untreated drinking water.

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) -

The BOD and COD tests were conducted and it was found that the values of these parameters were too low to be significant.

Total Organic Carbon (TOC) - The TOC is a measure of the organic matter in the water and is often related to BOD and COD. It was found that all samples were quite small (< 6.0 mg/l) which indicates that the river water contains only a very small quantity of oxygen demanding material.

WATER QUALITY ANALYSIS

BUFFALO NATIONAL RIVER, ARKANSAS

Date Sampled: May 22-23, 1973

TABLE 1

Parameter	Rush #8	St. Park #7	Hwy 14 #6	Gilbert #5	Hasty #4	Jasper #3	Shaddox #2	Boxley #1
Flow (cfs)	-----	-----	-----	-----	-----	-----	-----	-----
Temperature (⁰ C)	20	20	20	19	17.5	17	17	17
Dissolved Oxygen (mg/l)	-----	-----	-----	-----	-----	-----	-----	-----
pH	7.5	7.5	7.5	7.6	7.4	7.6	7.5	7.1
Color (Units)								
Turbidity (JTU)								
Nitrate (mg/l as N)								
Orthophosphate (mg/l as PO ₄)								
Alkalinity (mg/l as CaCO ₃)	140	120	120	110	70	80	70	25
Hardness (mg/l as CaCO ₃)	-----	-----	-----	-----	-----	-----	-----	-----
Chlorides (mg/l)	-----	-----	-----	-----	-----	-----	-----	-----
Conductivity (μ Mhos)	-----	-----	220	200	120	760	140	40
Suspended Solids (mg/l)	2.6	3.0	6.0	20.6	39.6	7.4	23.2	10.6
Total Solids (mg/l)	-----	-----	144	168	176	104	152	64
Coliforms, Total (Coli/100 ml)	0	0	130	0	5500	5000	300	30
Coliforms, Fecal (Coli/100 ml)	0	0	50	0	1500	670	150	0
Total Organic Carbon (mg/l)	2.1	2.1	2.9	1.9	5.6	-----	5.7	3.3

EQUIPMENT FAILURE

BUFFALO NATIONAL RIVER, ARKANSAS

Date Sampled: June 10-11, 1973

TABLE 2

Parameter	Rush #8	St. Park #7	Hwy 14 #6	Gilbert #5	Hasty #4	Jasper #3	Shaddox #2	Boxley #1
Flow (cfs)	----	----	----	----	----	----	----	----
Temperature (⁰ C)	22	23	23	22.5	22	19	21	22
Dissolved Oxygen (mg/l)	8.0	8.5	9.0	9.0	75	8.0	10	7.5
pH	7.6	7.6	7.8	7.7	7.5	7.5	7.6	7.3
Color (Units)	5	10	0	0	0	0	20	10
Turbidity (JTU)	5	0	0	0	0	0	5	5
Nitrate (mg/l as N)	0.60	0.20	0.45	0.12	0.09	0.18	0.26	0.08
Orthophosphate (mg/l as PO ₄)	0.8	0.5	0.4	0.2	0.2	0.2	0.5	0.1
Alkalinity (mg/l as CaCO ₃)	112	102	100	95	86	78	91	33
Hardness (mg/l as CaCO ₃)	-----	-----	-----	-----	-----	-----	-----	-----
Chlorides (mg/l)	2.8	2.8	2.8	2.8	2.8	4.2	2.8	2.8
Conductivity (μ Mhos)	160	140	140	140	130	120	140	50
Suspended Solids (mg/l)	8	11	9	16	5	5	5	5
Total Solids (mg/l)	67	75	67	63	75	72	80	16
Coliform, Total (Coli/100 ml)	220	100	27	200	330	1700	700	130
Coliform, Fecal (Coli/100 ml)	34	50	10	50	140	190	23	30
Total Organic Carbon (mg/l)	3.2	5.0	3.5	2.7	4.2	3.2	2.6	2.9

BUFFALO NATIONAL RIVER, ARKANSAS

Date Sampled: June 24-25, 1973

TABLE 3

Parameter	Rush #8	St. Park #7	Hwy 14 #6	Gilbert #5	Hasty #4	Jasper #3	Shadox #2	Boxley #1
Flow (cfs)	----	----	----	----	----	42	104	----
Temperature (⁰ C)	26	26	27	27	26	23	23	25
Dissolved Oxygen (mg/l)	7.2	7.4	8.9	8.5	8.5	7.4	8.0	8.4
pH	7.5	7.4	7.8	7.9	7.4	7.6	7.7	7.0
Color (Units)	0	0	0	0	0	0	0	0
Turbidity (JTU)	0	0	0	0	0	0	0	0
Nitrate (mg/l as N)	1.2	0.8	0.10	0.06	0.06	0.25	0.10	0.20
Orthophosphate (mg/l as PO ₄)	0.2	0.1	0.05	>0.05	0.2	>0.05	0.0	>0.05
Alkalinity (mg/l as CaCO ₃)	130	127	123	123	106	98	100	42
Hardness (mg/l as CaCO ₃)	148	136	117	111	105	95	109	43
Chlorides (mg/l)	1.5	1.5	1.5	1.0	1.5	1.5	1.0	0.5
Conductivity (μ Mhos)	250	240	240	220	200	200	220	90
Suspended Solids (mg/l)	1.4	2.7	2.3	2.2	3.5	3.0	3.6	4.8
Total Solids (mg/l)	152	141	120	125	119	111	127	60
Coliforms, Total (Coli/100 ml)	20	22	41	26	29	11000	230	2000
Coliforms, Fecal (Coli/100 ml)	130	7	-----	8	4	16000	150	200
Total Organic Carbon (mg/l)	2.1	1.7	2.7	2.1	1.8	4.5	2.9	2.2

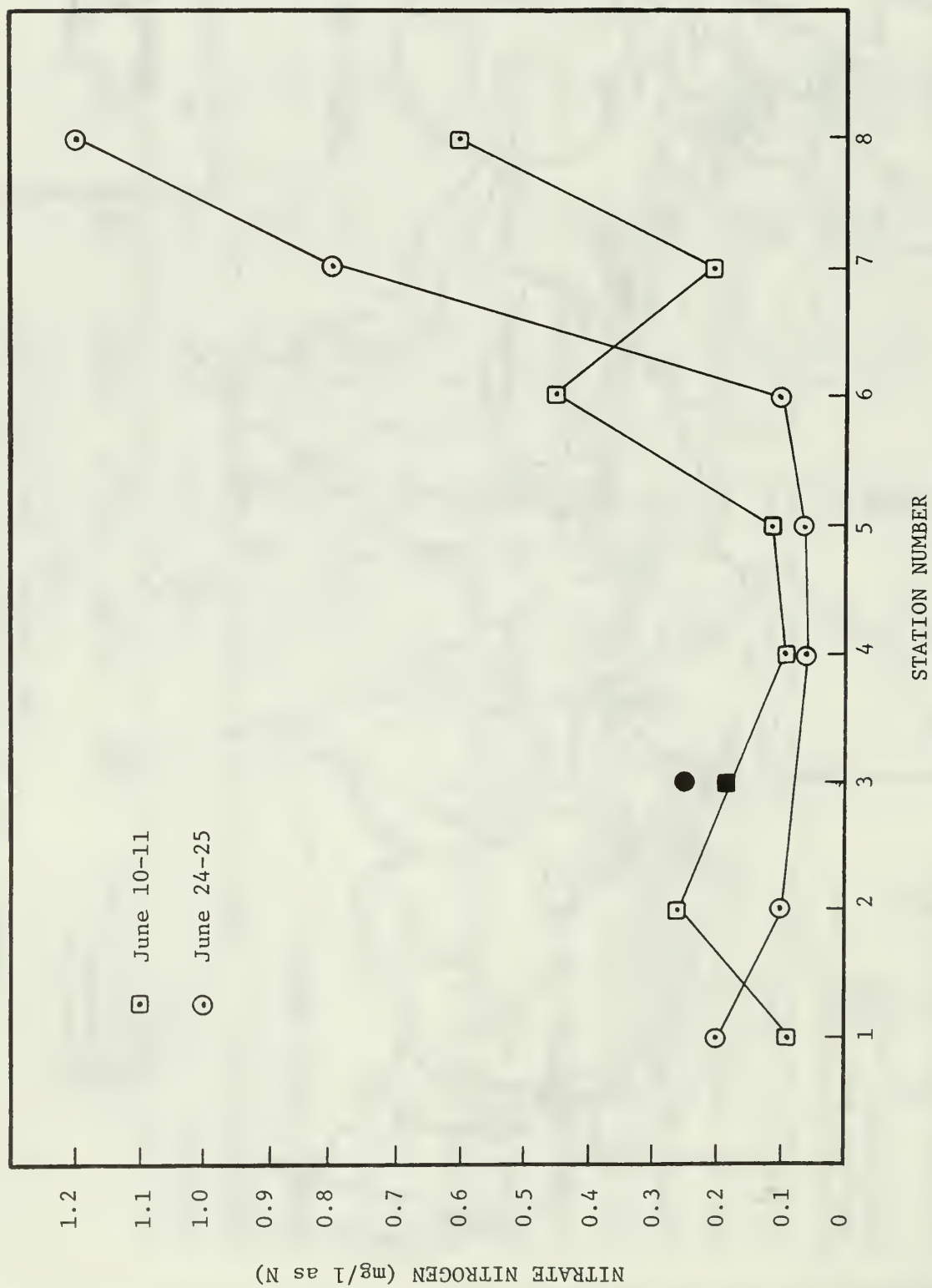


FIGURE 2: NITRATE NITROGEN

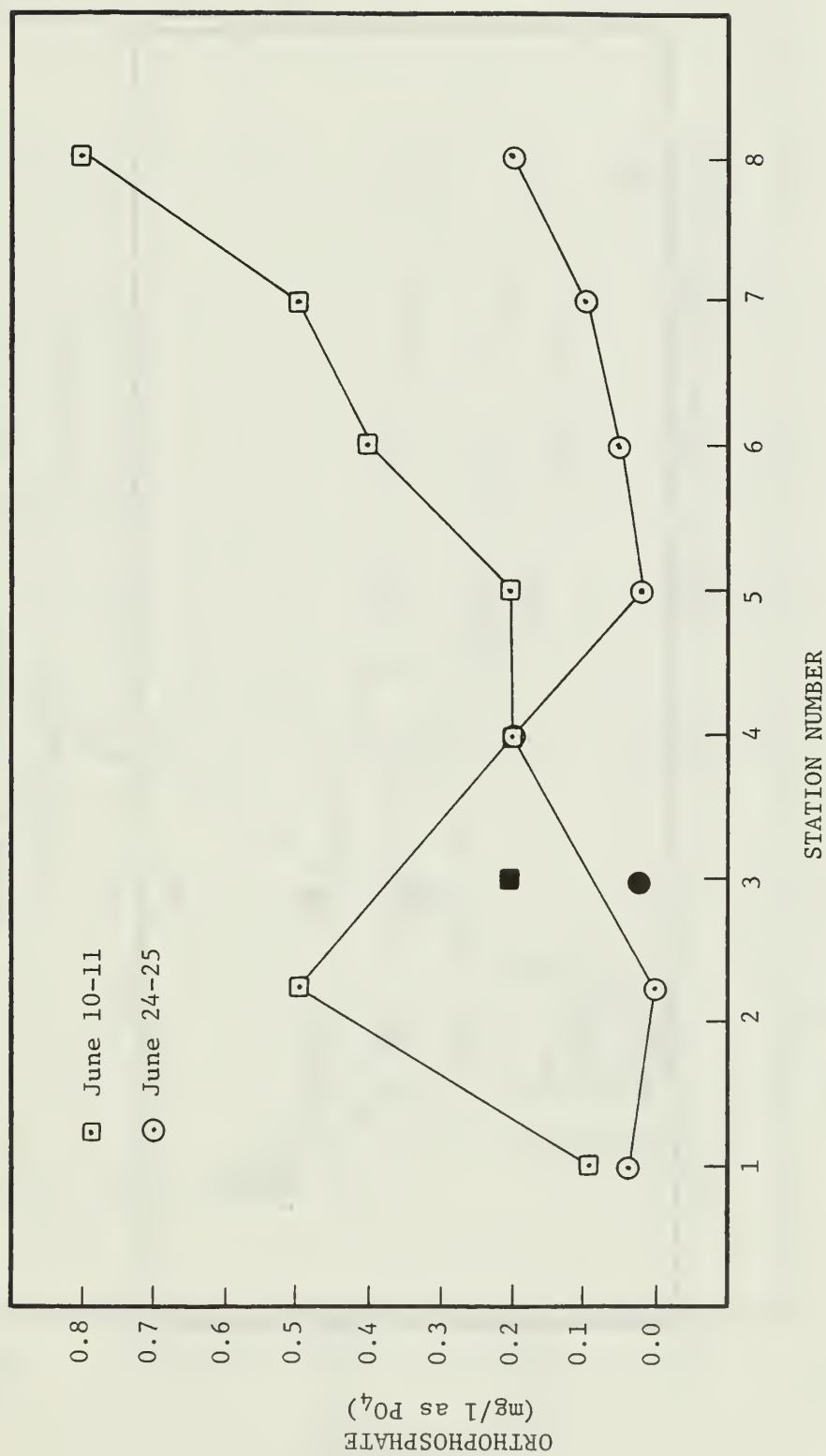


FIGURE 3: ORTHOPHOSPHATE

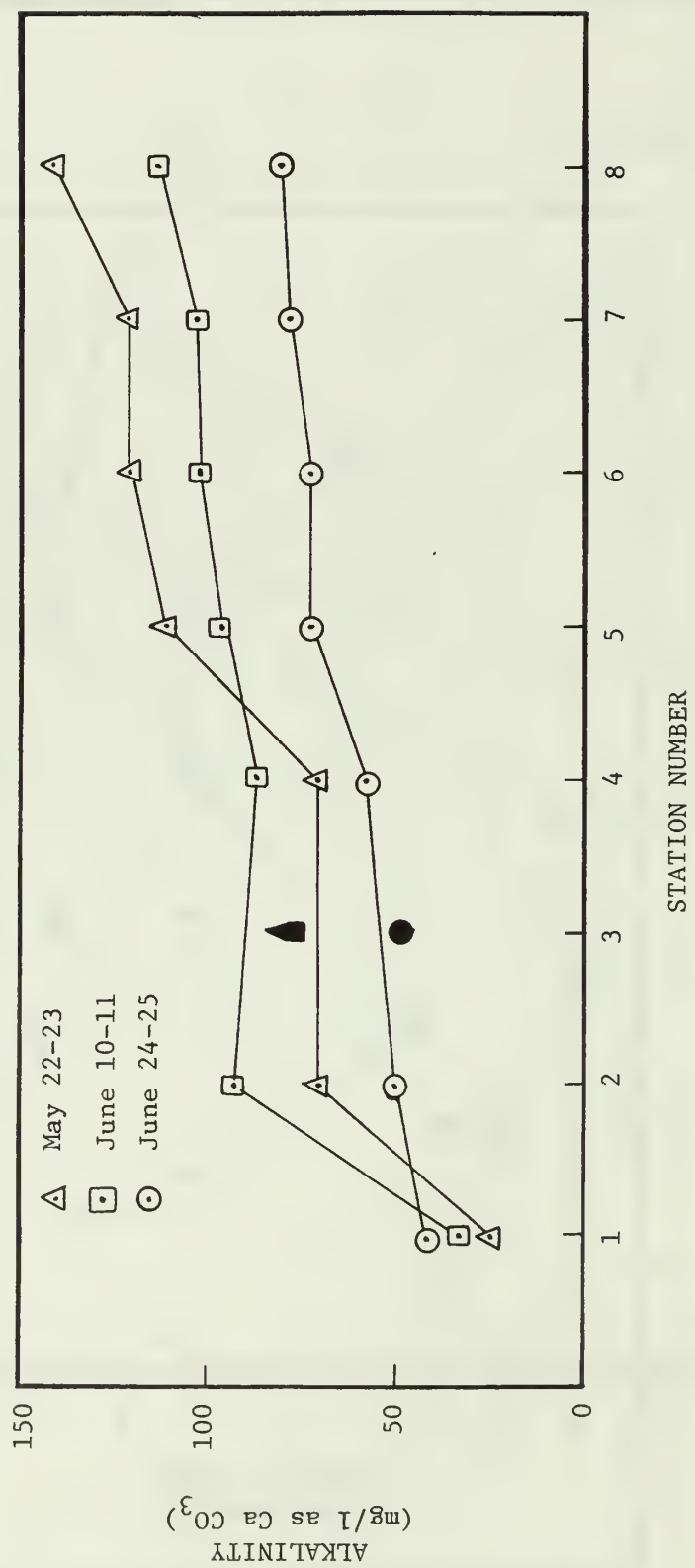


FIGURE 4: ALKALINITY

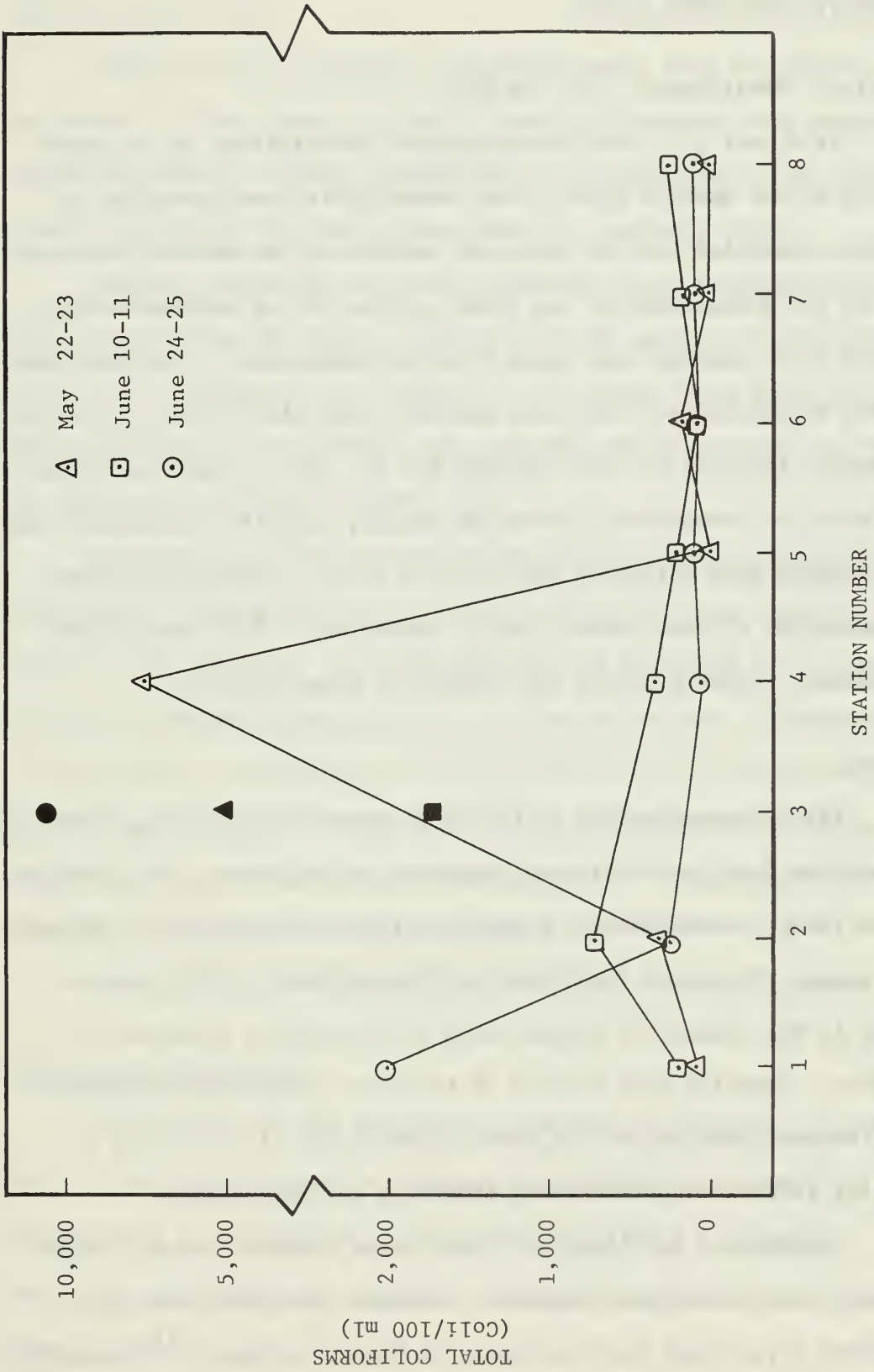


FIGURE 5: COLIFORM ORGANISMS

INTENSIVE "ONE SHOT" SURVEY

Principal Investigator: Dr. Joe Nix

As a part of a more comprehensive investigation of the water quality of the Buffalo River, this investigation was conducted to provide a detailed look at the water quality of the Buffalo River and some of its tributaries at one point in time (5 day reconnaissance). A total of 34 samples were taken from the mainstream of the river and 22 from tributaries of the river between river mile 33 and 137 during the period from May 22, 1973 through May 27, 1973. Field measurements were made for temperature, dissolved oxygen, specific conductance, and pH. Samples were collected and returned to the laboratory for the determination of other water quality parameters. This part of the preliminary report provides the results of these analysis.

Methods

Field reconnaissance of the river between river mile 138 and 128 was made by driving to selected locations on the river. The remainder of the field reconnaissance, river mile 128 to river mile 33, was made from canoe. The canoe trip began at Ponca on May 23, 1973 and extended to the Highway 14 bridge south of Yelleville, Arkansas on May 27th. Sampling this section of the river from canoes permitted more frequent sampling of the main stream of the river as well as sampling tributaries which would otherwise be inaccessible.

Temperature and dissolved oxygen were measured using a Yellow Springs Dissolved Oxygen Analyser. The meter was calibrated for dissolved oxygen each morning using the Winkler method. [1] Specific conductance was measured using a Yellow Springs S-C-T Meter. The pH of each sample was measured immediately after collection using

a Hach color comparator. Bromothymol blue and chlorophenol red indicators were used.

Samples were collected in sterile plastic bags and packed in an ice chest. In the laboratory the following parameters were measured: sodium, potassium, calcium, magnesium, iron, manganese, zinc, chloride, fluoride, sulfate, nitrate, ortho-phosphate, and alkalinity.

Sodium, potassium, calcium, magnesium, iron, manganese, and zinc were measured by direct aspiration of the sample into the flame of an atomic absorption spectrometer. The Perkin Elmer Model 303 Atomic Absorption Spectrometer was used with the instrument settings recommended by the manufacturer. [2]

Chloride and fluoride were measured with Orion selective ion electrodes. Nitrate was measured polarographically as described by Frazier. [3] Phosphate was determined by the formation of the phosphomolydic acid and subsequent extraction with chloroform-tutanol. The absorbance of the extract was measured at 310 millimicrons as described by Waldelin and Mellon. [4] Sulfate was determined using the barium Chloranalate method described by Bertolacini.[5] Alkalinity was measured as described in Standard Methods.[1]

The location of sampling points is given in Table Number 4 and 5.

Results and Discussion

The results of the analysis of samples are presented in Tables 6 and 7. The data for samples taken on the mainstream of the river are also plotted as a function of river mile in Figures 6 through 21. The range and mean values for the data for the mainstream of the river are given in Table 8.

TABLE NUMBER 4

Location of points which were sampled on the main stream of the Buffalo River.

SAMPLE NUMBER	DATE SAMPLED	LOCATION	APPROXIMATE RIVER MILE
1	5/22/73	at Hedges home above Boxley	138
4	5/23/73	Ponca Bridge	128
5	5/23/73	Wrecking Rock	126
8	5/23/73	confluence of Sneeds Creek	121
9	5/23/73	above confluence with Indian Creek	118
10	5/23/73	Camp Orr	116
12	5/24/73	2.5 miles below Camp Orr	113
15	5/24/73	0.5 miles above confluence with Sawmill Hollow	109
16	5/24/73	Highway 7 bridge	104
19	5/24/73	1/4 mile above confluence with Boomer Hollow	101
21	5/24/73	confluence with Wells Creek	98
23	5/24/73	1/4 mile below Hasty bridge	96
25	5/24/73	Highway 125 bridge	93
26	5/25/73	2 1/2 mile below confluence with Big Creek	91
28	5/25/73	1 1/2 mile upstream from Mt. Hersey	88
30	5/25/73	Mt. Hersey	86
32	5/25/73	confluence with Cane Creek	83
33	5/25/73	The "Naars"	80

TABLE NUMBER 4 CONTINUED

SAMPLE NUMBER	DATE SAMPLED	LOCATION	APPROXIMATE RIVER MILE
35	5/25/73	confluence with Richland Creek	78
37	5/25/73	1/2 mile above White Ford	74
38	5/25/73	near Peter Cave	69
40	5/25/73	Red Bluff	67
41	5/26/73	Arnold Bend	66
43	5/26/73	immediately downstream from confluence with Calf Creek	64
44	5/26/73	Highway 65 bridge	62
46	5/26/73	Gilbert	57
48	5/26/73	below confluence with Ezell Hollow	52
50	5/26/73	above confluence with Tomahawk Creek	49
51	5/26/73	1 1/2 mile above Maumee	46
52	5/27/73	1/2 mile above Maumee	45
54	5/27/73	4 1/2 mile below Maumee	40
56	5/27/73	1 mile below confluence with Spring Creek	38
58	5/27/73	at confluence with Water Creek	35
59	5/27/73	at Highway 14 bridge	33

TABLE NUMBER 5

Location of points which were sampled on tributaries of the Buffalo River. All tributaries were sampled at their confluence with the Buffalo River.

SAMPLE NUMBER	DATE SAMPLED	LOCATION	APPROXIMATE RIVER MILE OF CONFLUENCE
6	5/23/73	Steel Creek	122
7	5/23/73	Sneeds Creek	118
13	5/24/73	Webb Branch	109
14	5/24/73	North tributary south of Conard Fishure	108
17	5/24/73	Mill Creek At Pruitt	101
18	5/24/73	North tributary upstream from Boomer Hollow	98
20	5/24/73	Little Buffalo River	97
22	5/24/73	Wells Creek	96
24	5/24/73	Big Creek at Highway 125	91
27	5/25/73	North tributary 1 1/2 mile upstream from Mt. Hersey	85
29	5/25/73	Davis Creek at Mt. Hersey	84
31	5/25/73	Cane Creek	80
34	5/25/73	Richland Creek	75
36	5/25/73	Ben Branch	72
39	5/25/73	Ricky Hollow	65
42	5/26/73	Calf Creek	61
45	5/26/73	Dry Creek at Gilbert	54
49	5/26/73	Tomohawk Creek	49

TABLE NUMBER 5 CONTINUED

SAMPLE NUMBER	DATE SAMPLED	LOCATION	APPROXIMATE RIVER MILE OF CONFLUENCE
52-S	5/26/73	Spring on west bank of river 1 mile upstream from Maumee	44
53	5/27/73	Maumee Hollow	43
55	5/27/73	Spring Creek	39
57	5/27/73	Water Creek	35

Thundershowers had occurred throughout the Buffalo River watershed on May 21, 1973. There were also small showers throughout the upper basin on the evening of May 22. Rainfall amounts were generally under one inch in the upper watershed with even smaller quantities in the lower watershed. On May 22, 1973 at the beginning of the canoe trip, the river was moderately turbid. During the course of the next four days, the river gradually cleared.

On the evening of May 26, 1973 heavy rains were experienced through-out the basin. Several tornados and associated high winds were reported throughout the northern half of Arkansas. A considerable rise in the river had occurred by the morning of May 27. The river was also very turbid. The break in continuity of several of the parameters at river mile 45 is no doubt due to the presence of heavy runoff. Due to the rise in the river and the break in continuity of the study, the trip was terminated at river mile 33. Data taken between river mile 45 and 33 reflect the condition of the river after a substantial rise.

A gradual increase in temperature was observed in a downstream direction. This increase may simply be due to fluctuations in cloud cover during the course of the investigation.

As shown in Figure 7, dissolved oxygen values in the mainstream of the river were near or well above saturation values. Dissolved oxygen values on tributaries were also near and above saturation. This would indicate that there were no organic loading problems present on the section of the river which was surveyed. However, organic loading problems may become more apparent during extreme low flow periods.

The pH of the mainstream of the river increases rather sharply in the headwater then stabilizes between 7.5 and 8.0. Although it was

impossible to show direct correlation, pH measurements made early in the morning were generally lower than values observed later in the day. Such fluctuations would be expected to occur in a moderately productive river.

The conductivity meter used to measure specific conductance malfunctioned near river mile 68 and measurements could not be made after that time. As shown in Figure 8, specific conductance increases sharply in a downstream direction. From these data it is clear that the river gradually continues to dissolve material from sediment as it flows.

The calcium content of the river also increases in a downstream direction, generally adding approximately 10 ppm of calcium for every 25 to 30 river miles. These data along with magnesium, alkalinity, and sulfate indicate that the river is trending toward equilibrium with carbonate and sulfate sediments in the river. For a system in equilibrium with the atmosphere and CaCO_3 , the pH is 8.4 [6]. The fact that the pH values observed on the mainstream of the river are well below this number would indicate that the river was not at equilibrium with the carbonate sediments.

As shown in Figure 10, a decrease in the calcium concentration of the river was observed after the heavy rains of late May 26 and early May 27. Apparently the river was recovering its original calcium content before the final sample was taken at river mile 33 on May 27. This would suggest that although there is probably a dilution effect from moderately heavy runoff, the river may recover rather fast. Further studies should be conducted to investigate this aspect of the chemistry of the river.

The break in the continuity of the magnesium data at river mile 80 is rather striking. An inspection of Table 5 shows that near river

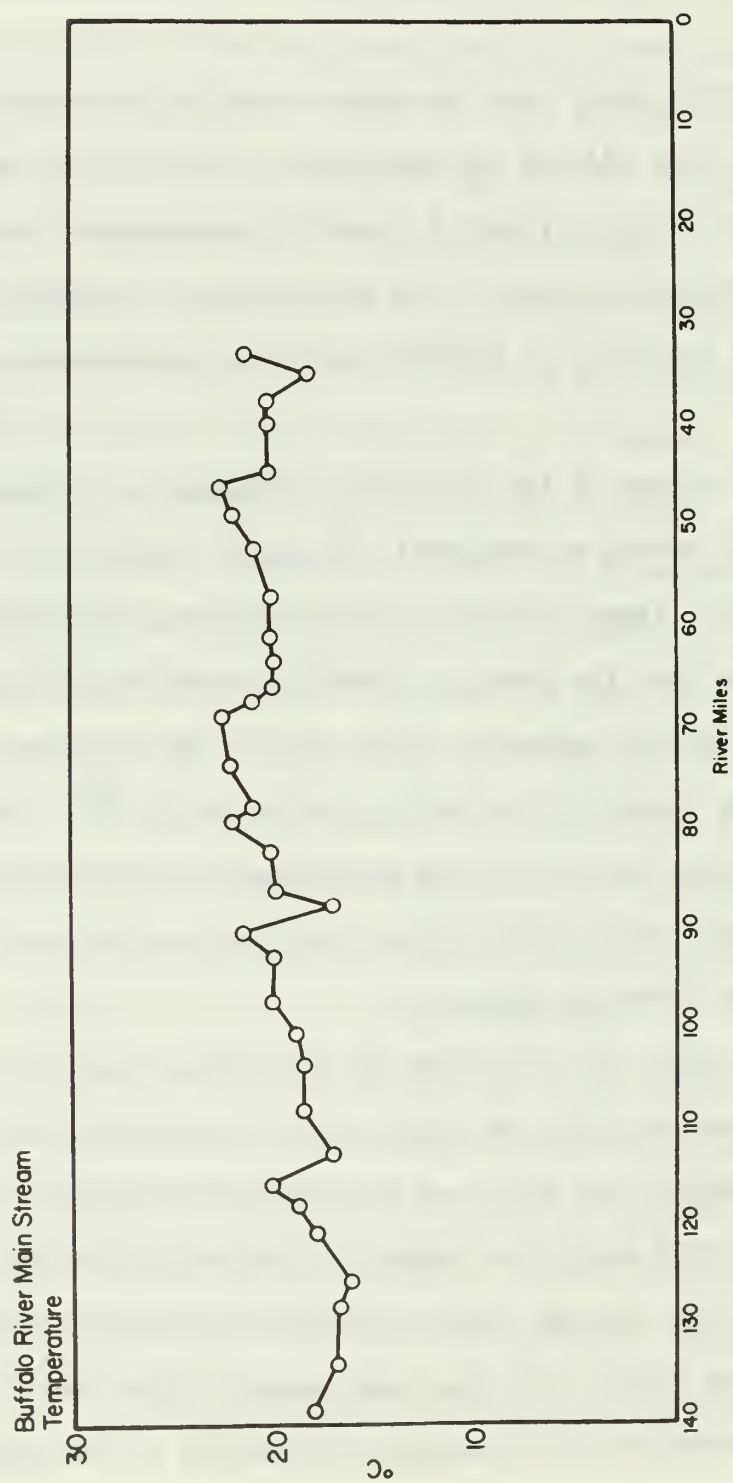


Figure 6

Temperature, Mainstream Buffalo
River May 22 through May 27, 1973

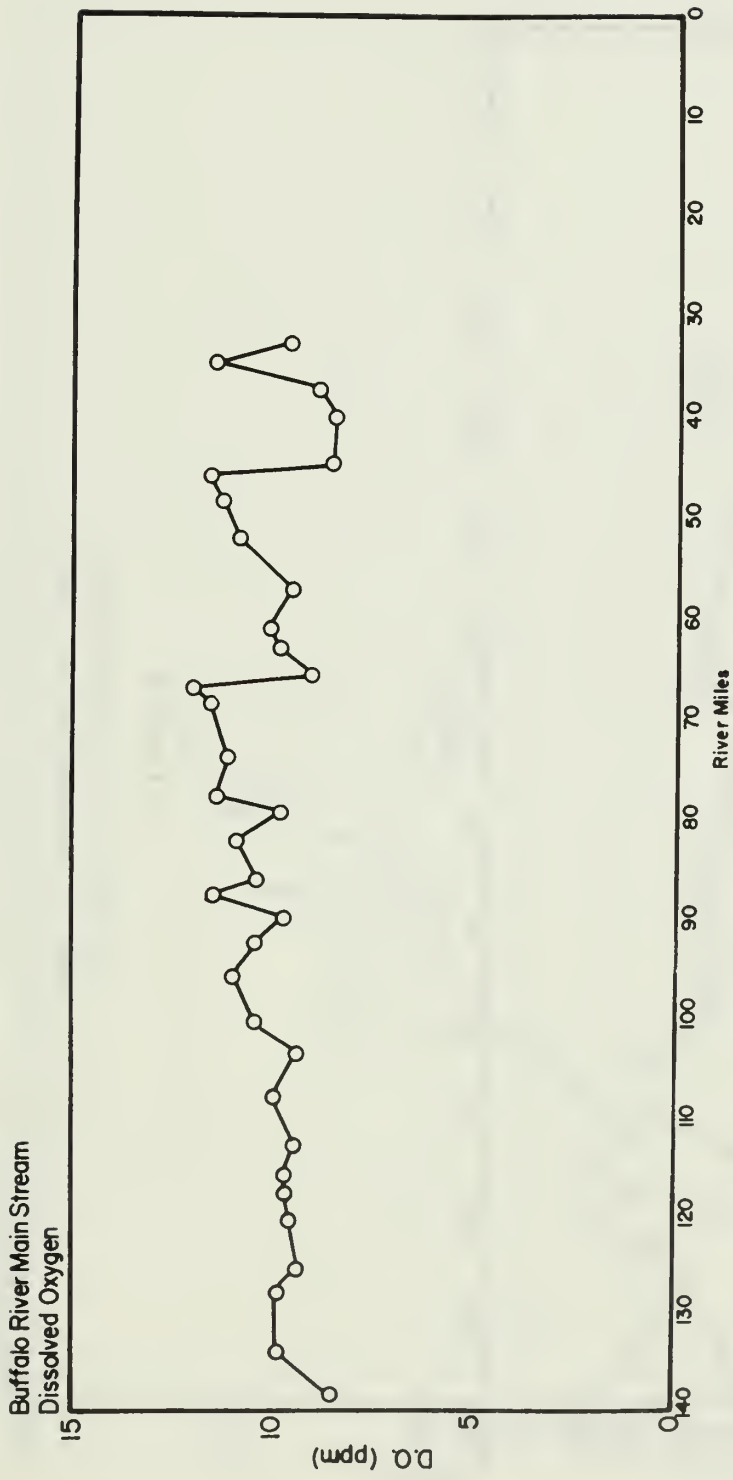


Figure 7

Dissolved Oxygen, Mainstream
Buffalo River May 22 through May
27, 1973

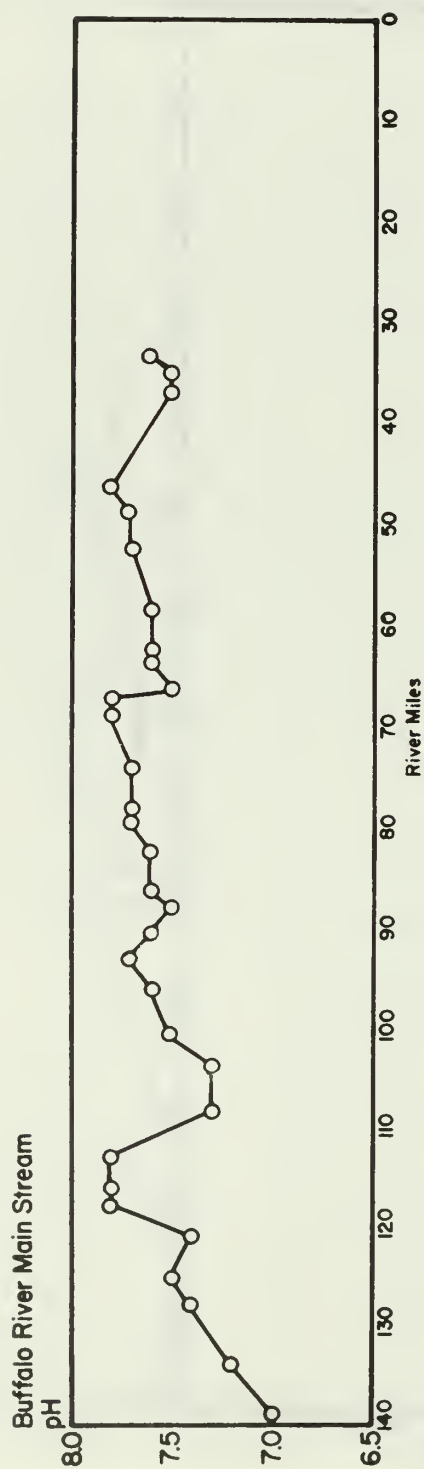


Figure 8
pH, Mainstream Buffalo River
May 22 through May 27, 1973

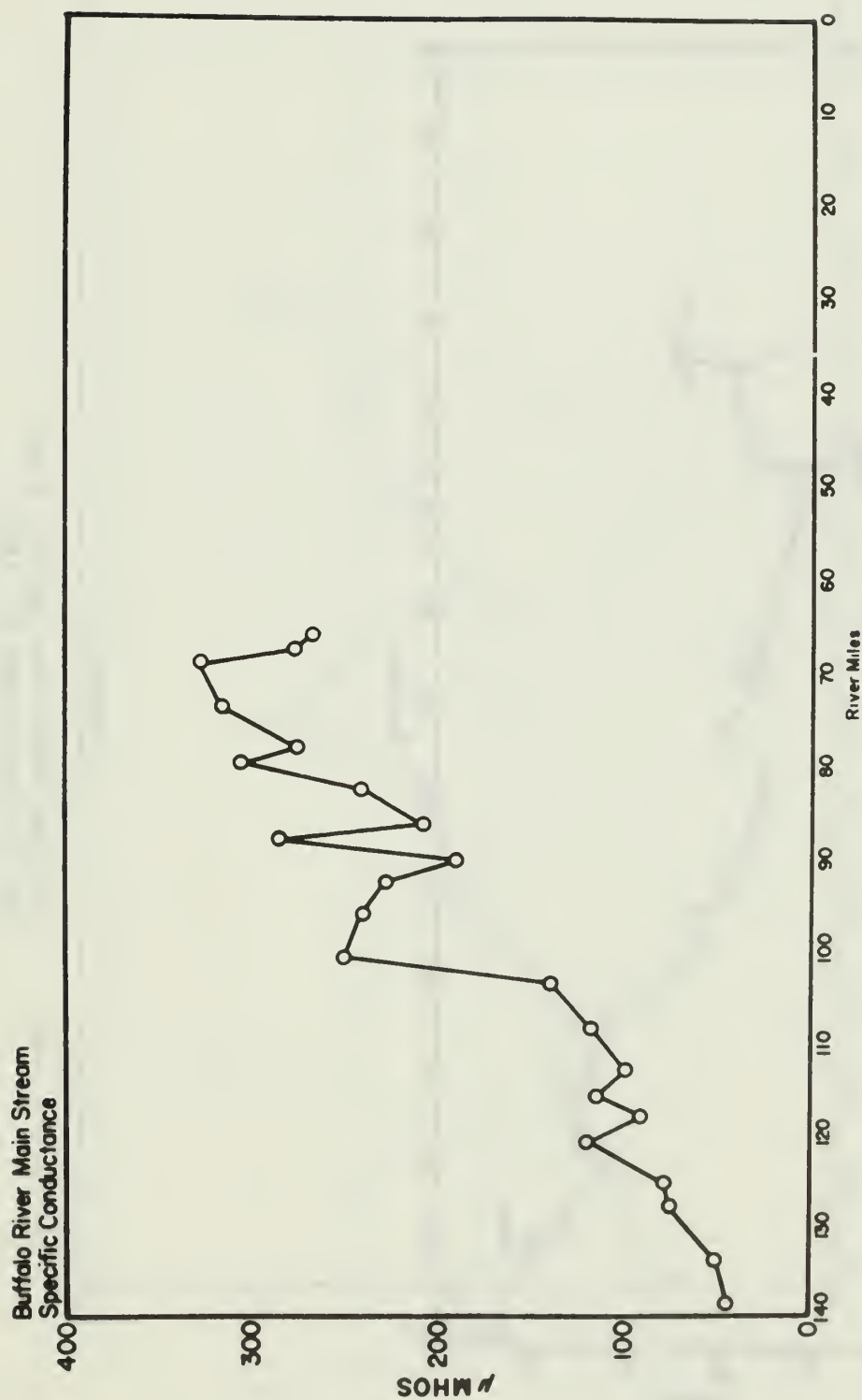


Figure 9

Specific Conductance, Mainstream
Buffalo River May 22 through May
27, 1973

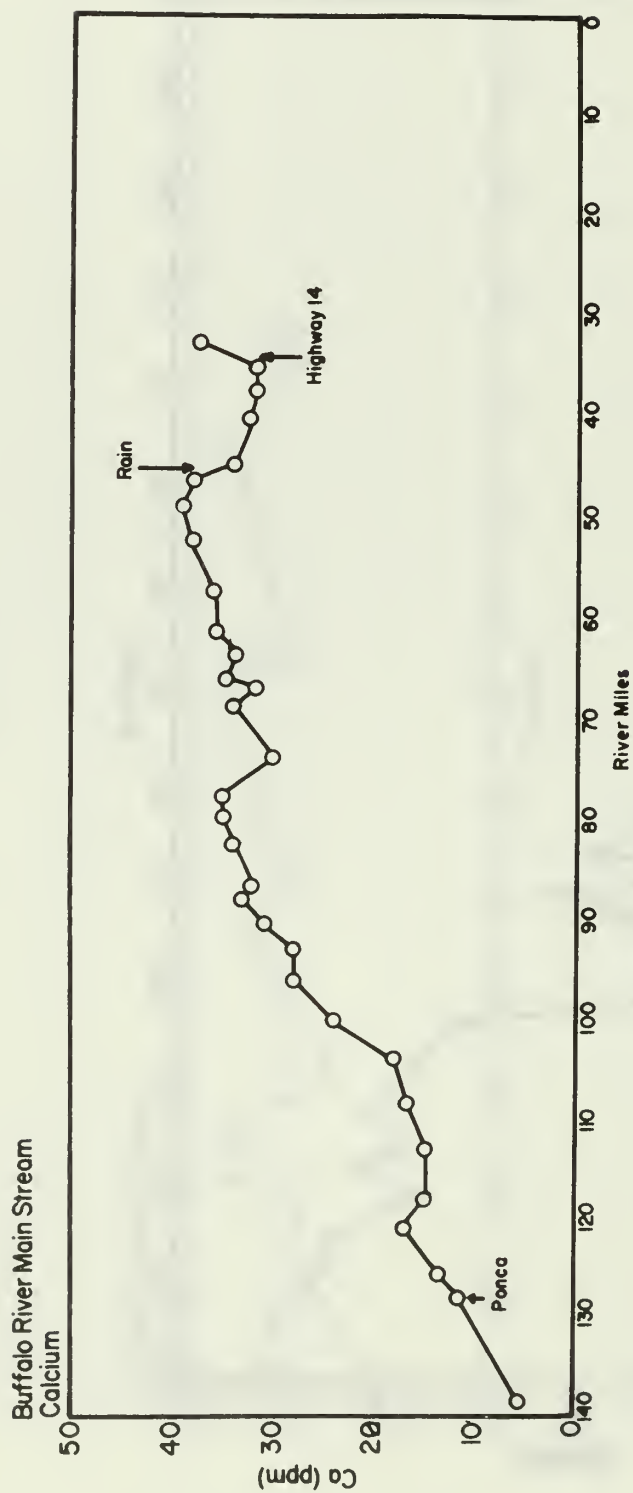


Figure 10

Calcium, Mainstream Buffalo River
May 22 through May 27, 1973

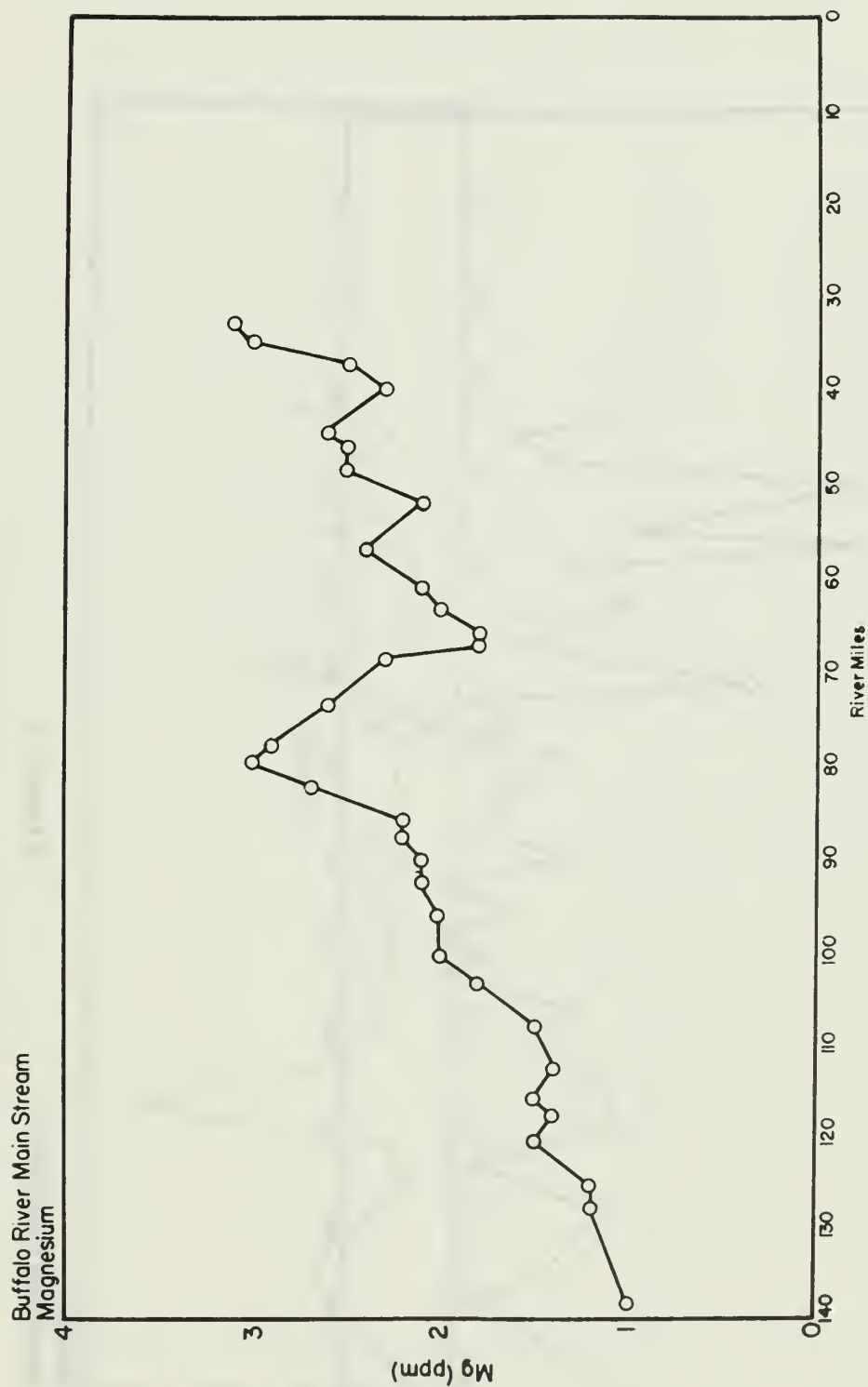


Figure 11

Magnesium, Mainstream Buffalo
River May 22 through May 27, 1973

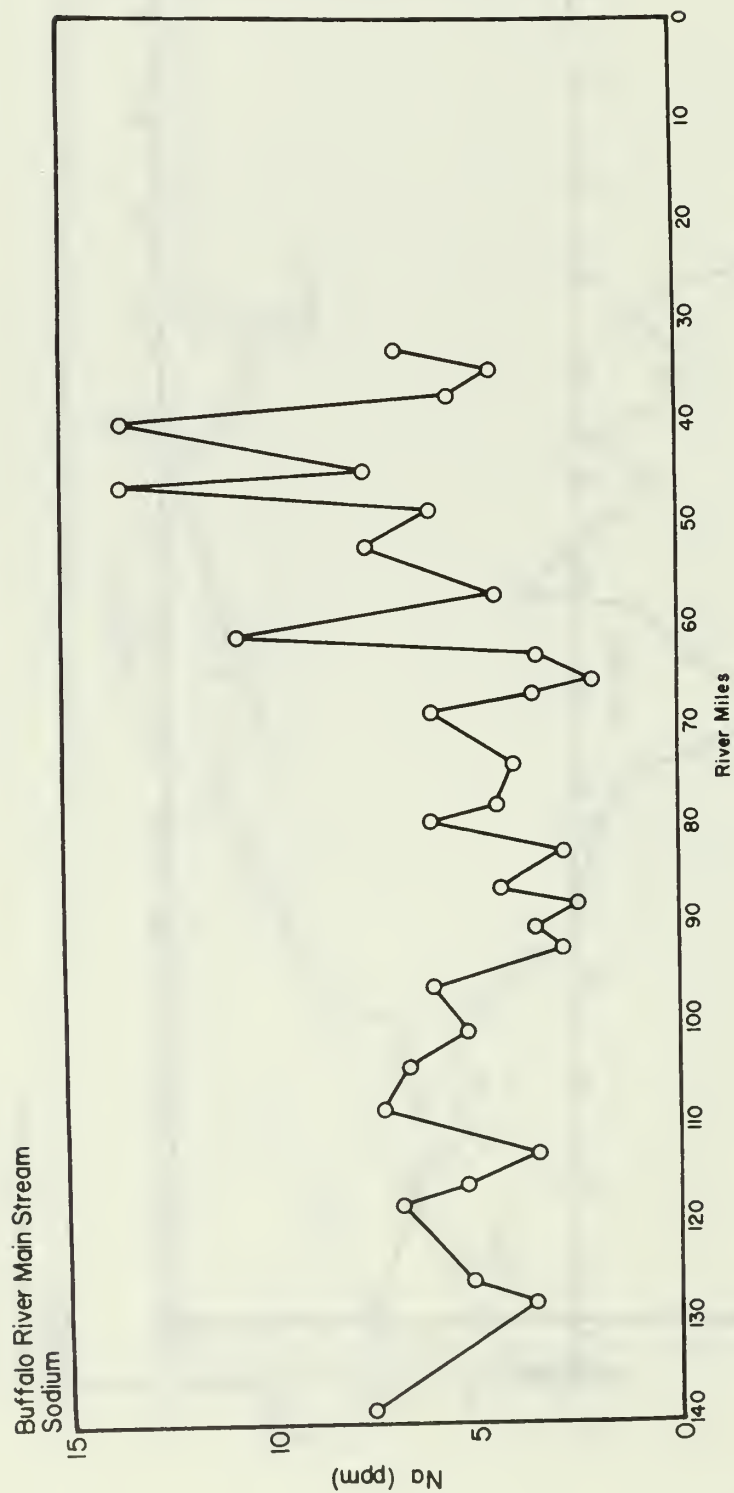


Figure 12

Sodium, Mainstream Buffalo River
May 22 through May 27, 1973

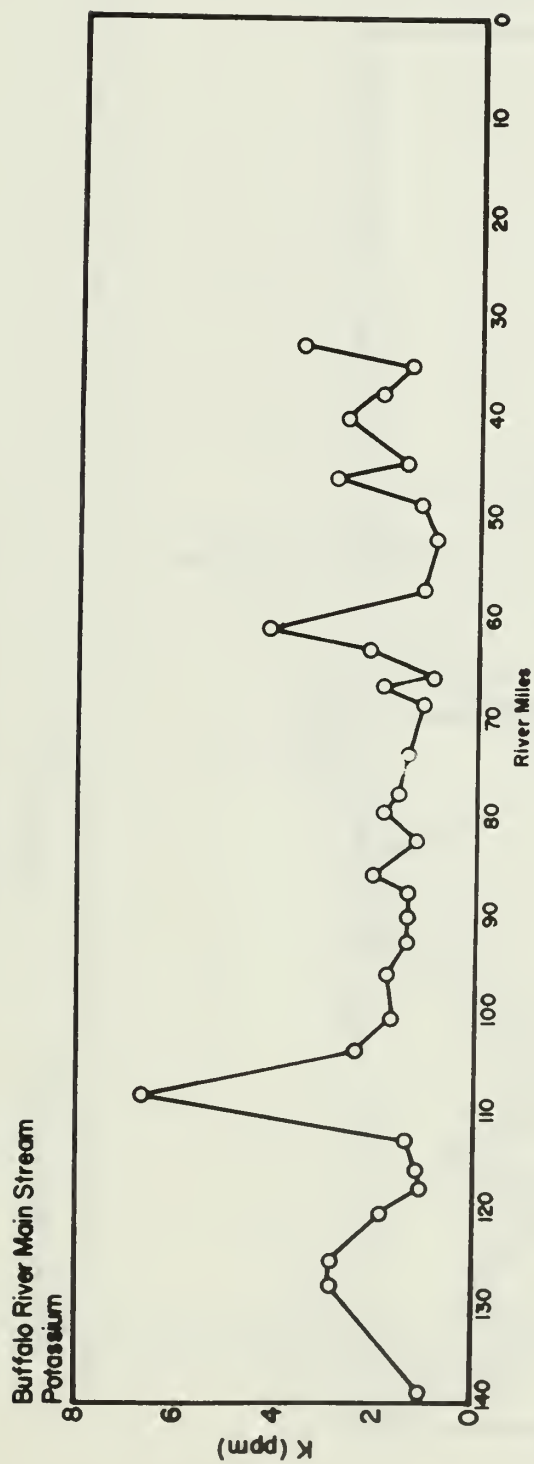


Figure 13
Potassium, Mainstream Buffalo
River May 22 through May 27, 1973

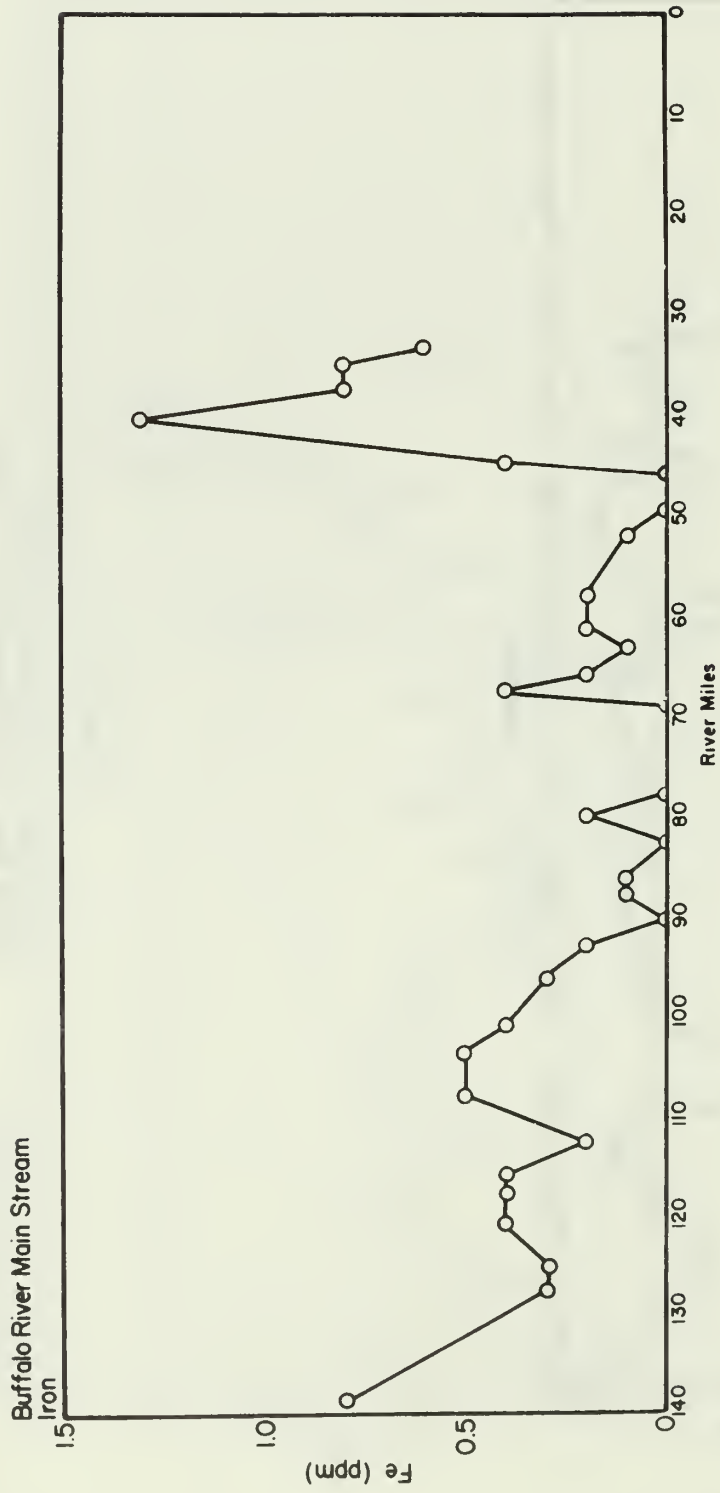


Figure 14

Iron, Mainstream Buffalo River
May 22 through May 27, 1973

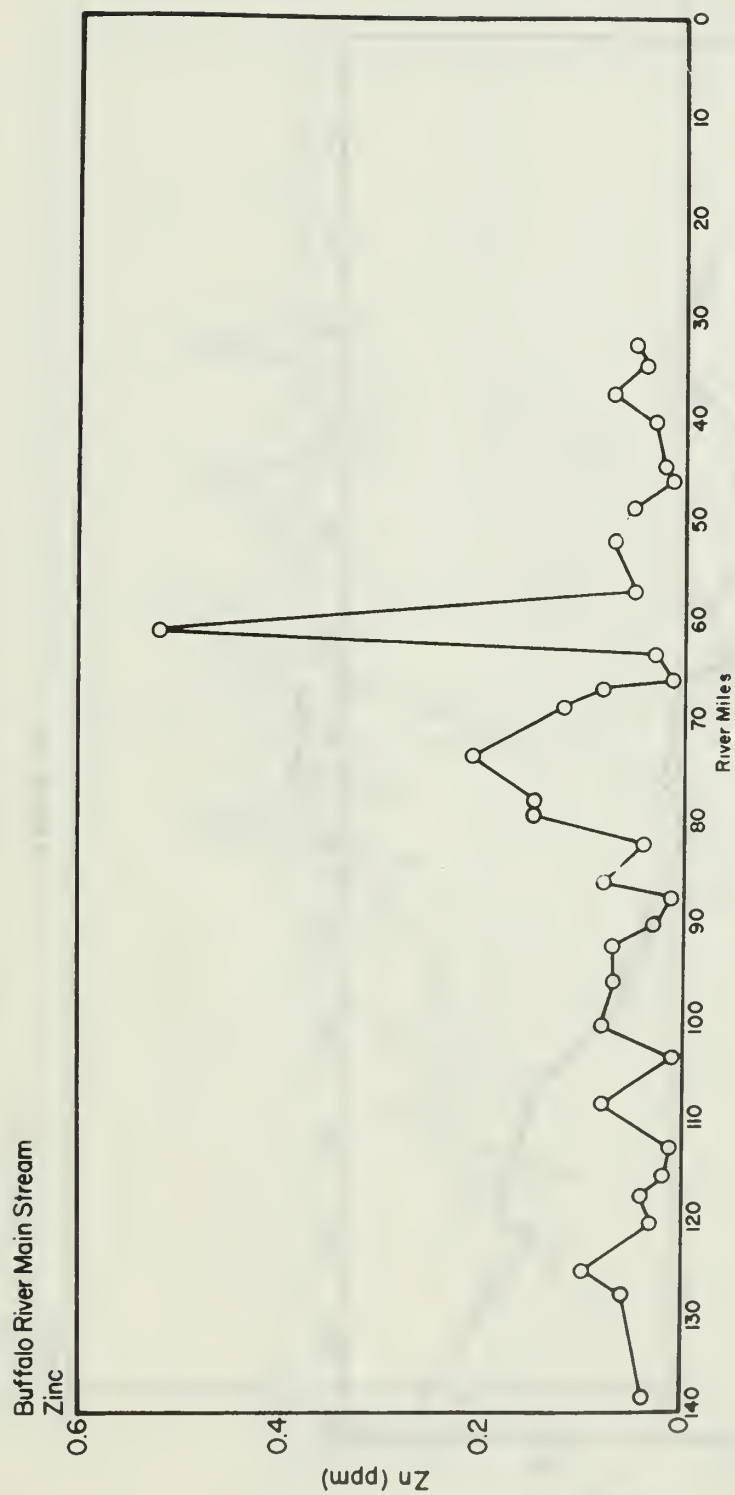


Figure 15

Zinc, Mainstream Buffalo River May
22 through May 27, 1973

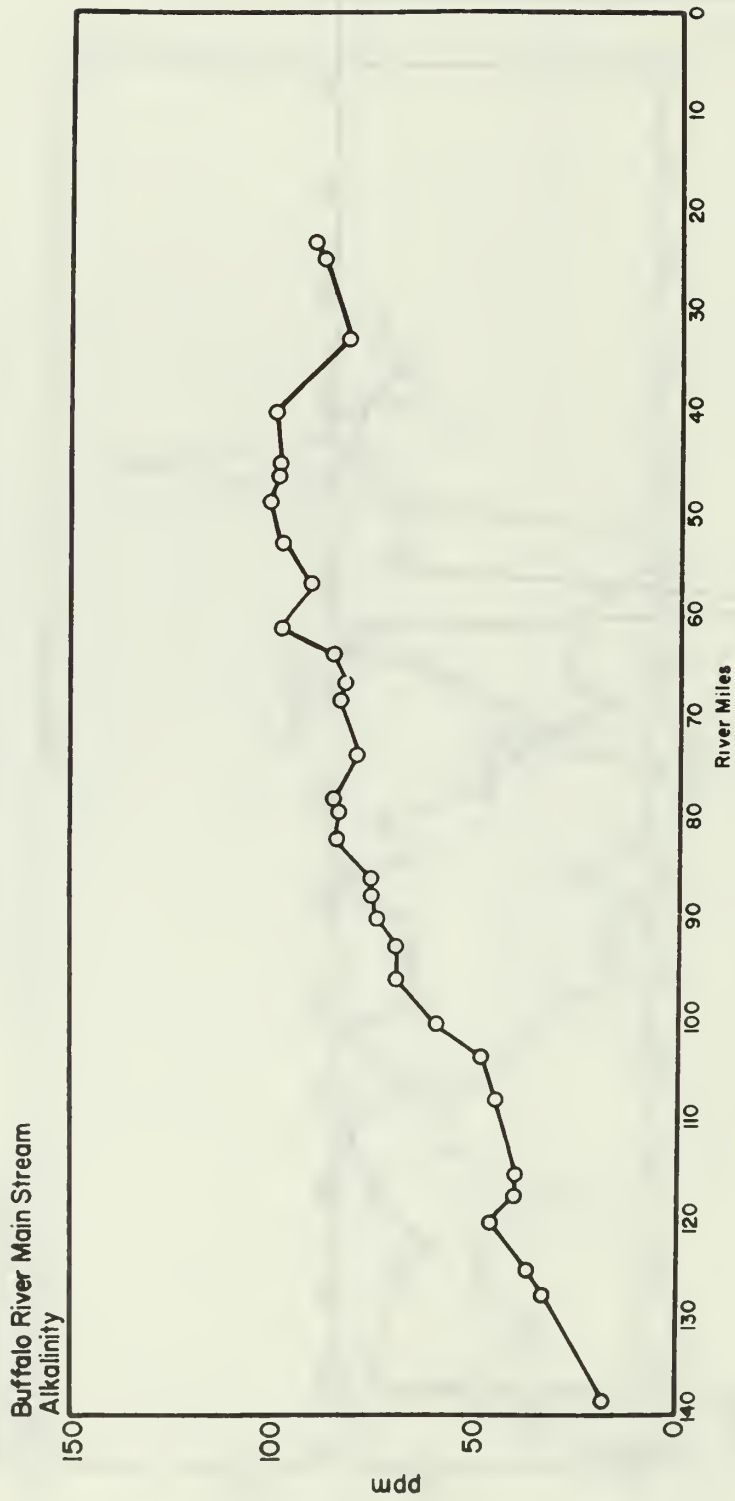


Figure 16

Alkalinity, Mainstream Buffalo
River May 22 through May 27, 1973

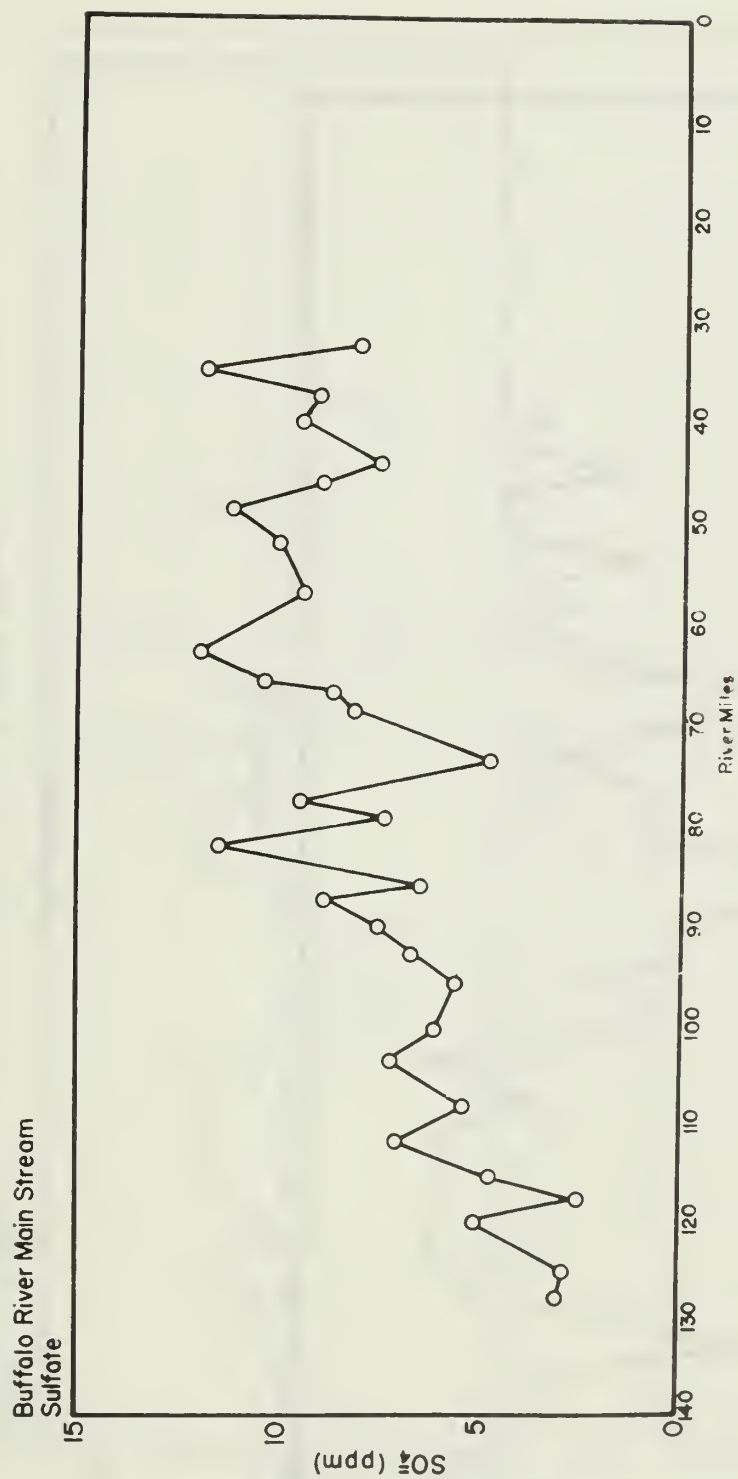


Figure 17

Sulfate, Mainstream Buffalo River
May 22 through May 27, 1973

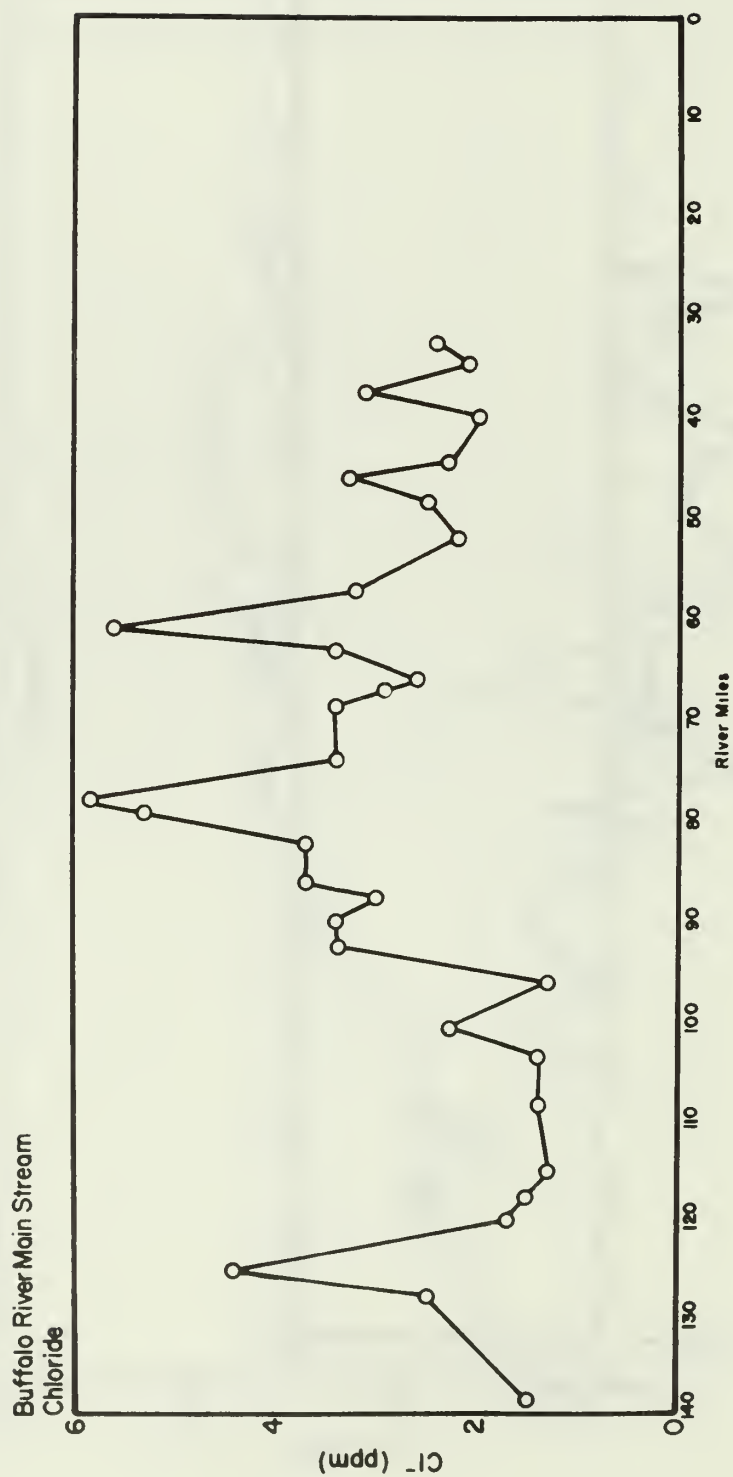


Figure 18

Chloride, Mainstream Buffalo River
May 22 through May 27, 1973

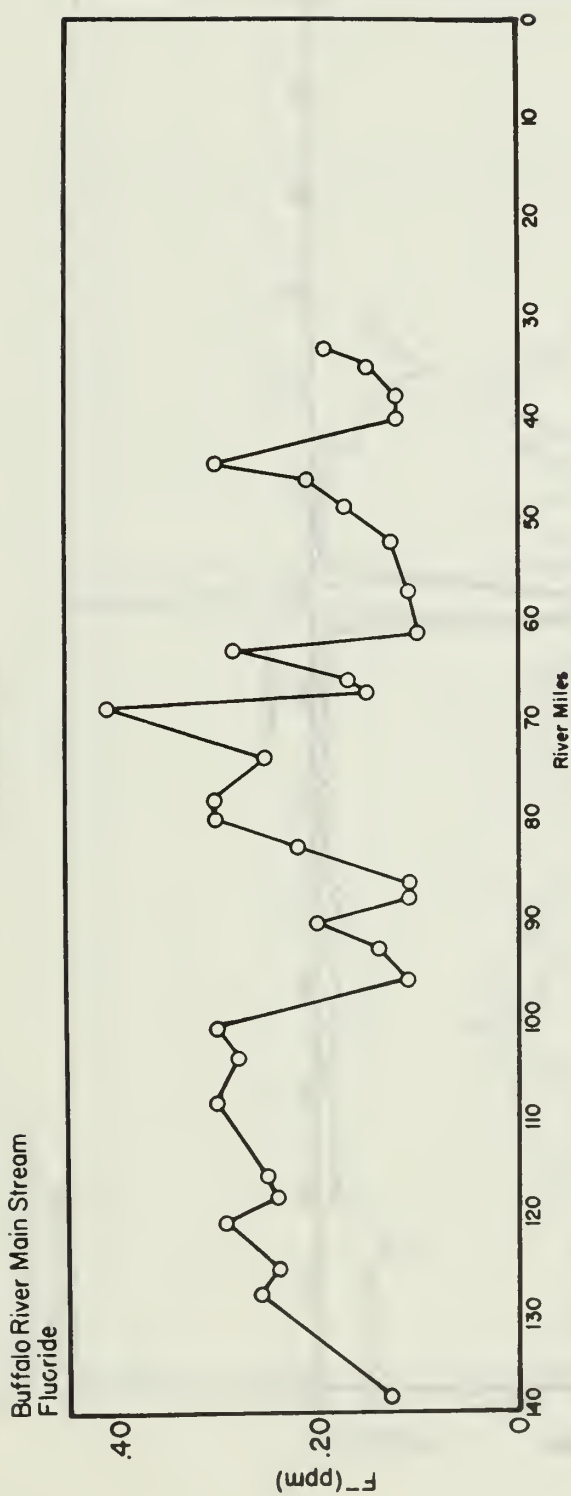


Figure 19

Fluoride, Mainstream Buffalo
River May 22 through May 27, 1973

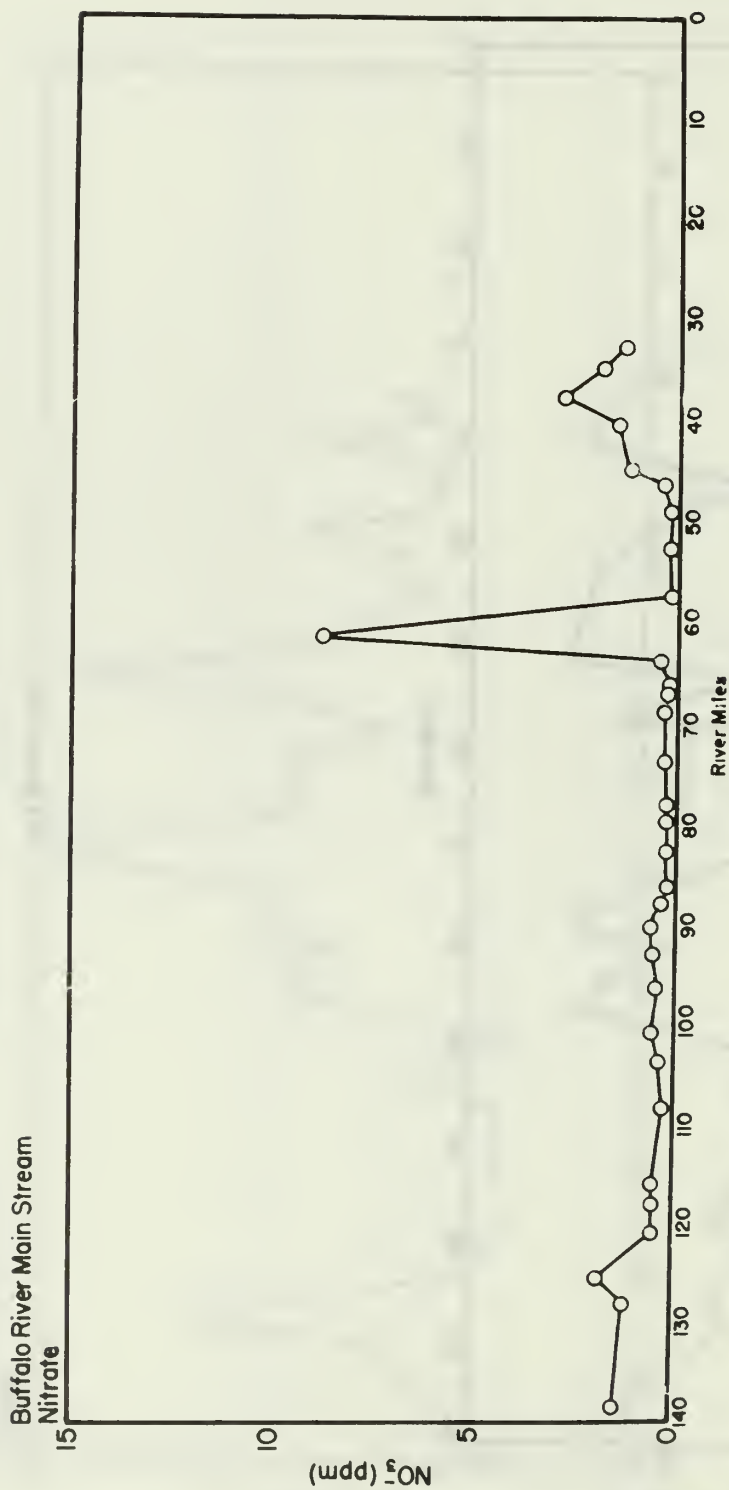


Figure 20

Nitrate, Mainstream Buffalo
River May 22 through May 27, 1973



Figure 21

Phosphate, Mainstream Buffalo
River May 22 through May 27, 1973

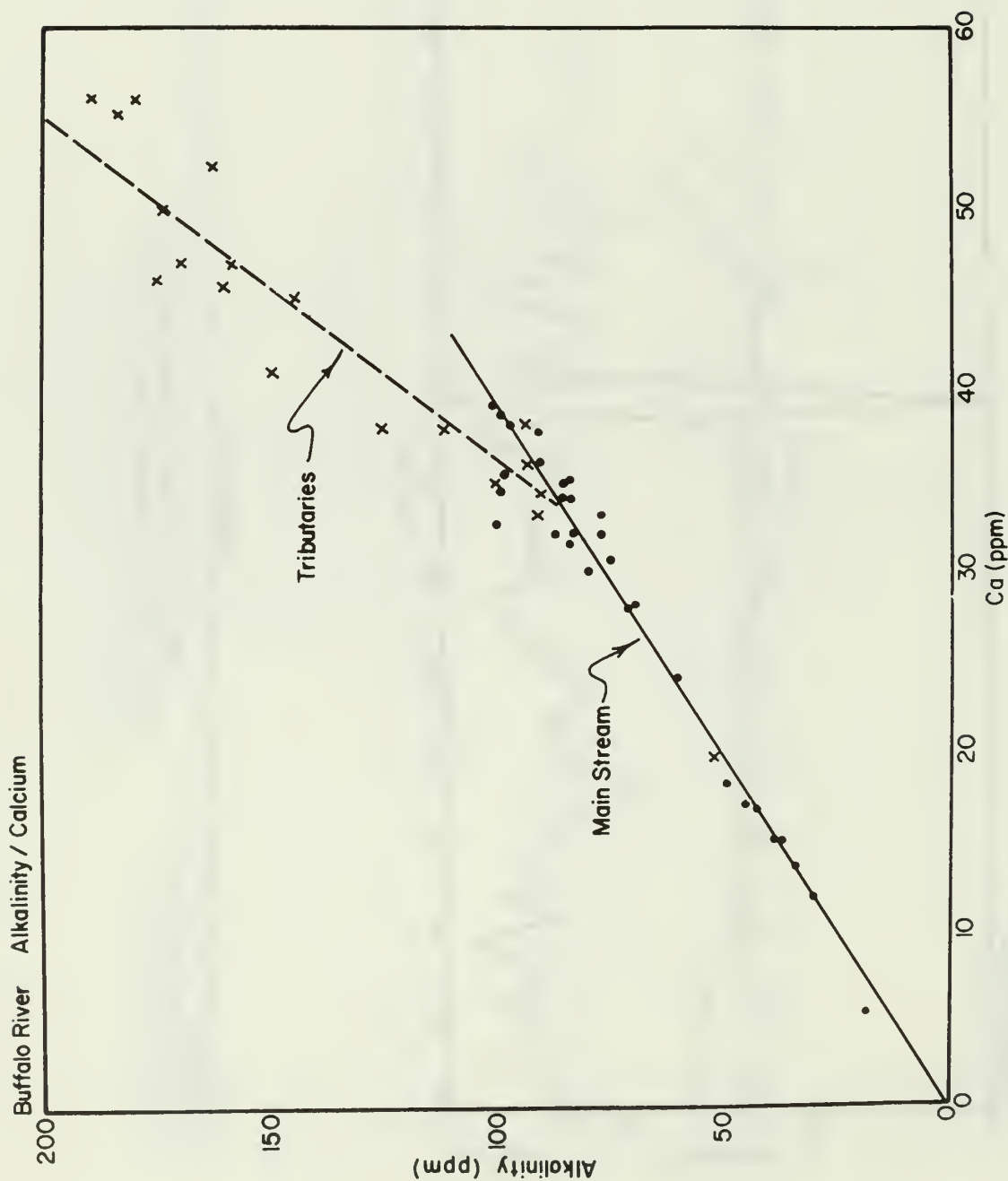


Figure 22

Alkalinity versus Calcium Concentration for Mainstream and Tributaries of Buffalo River May 22 through May 27, 1973

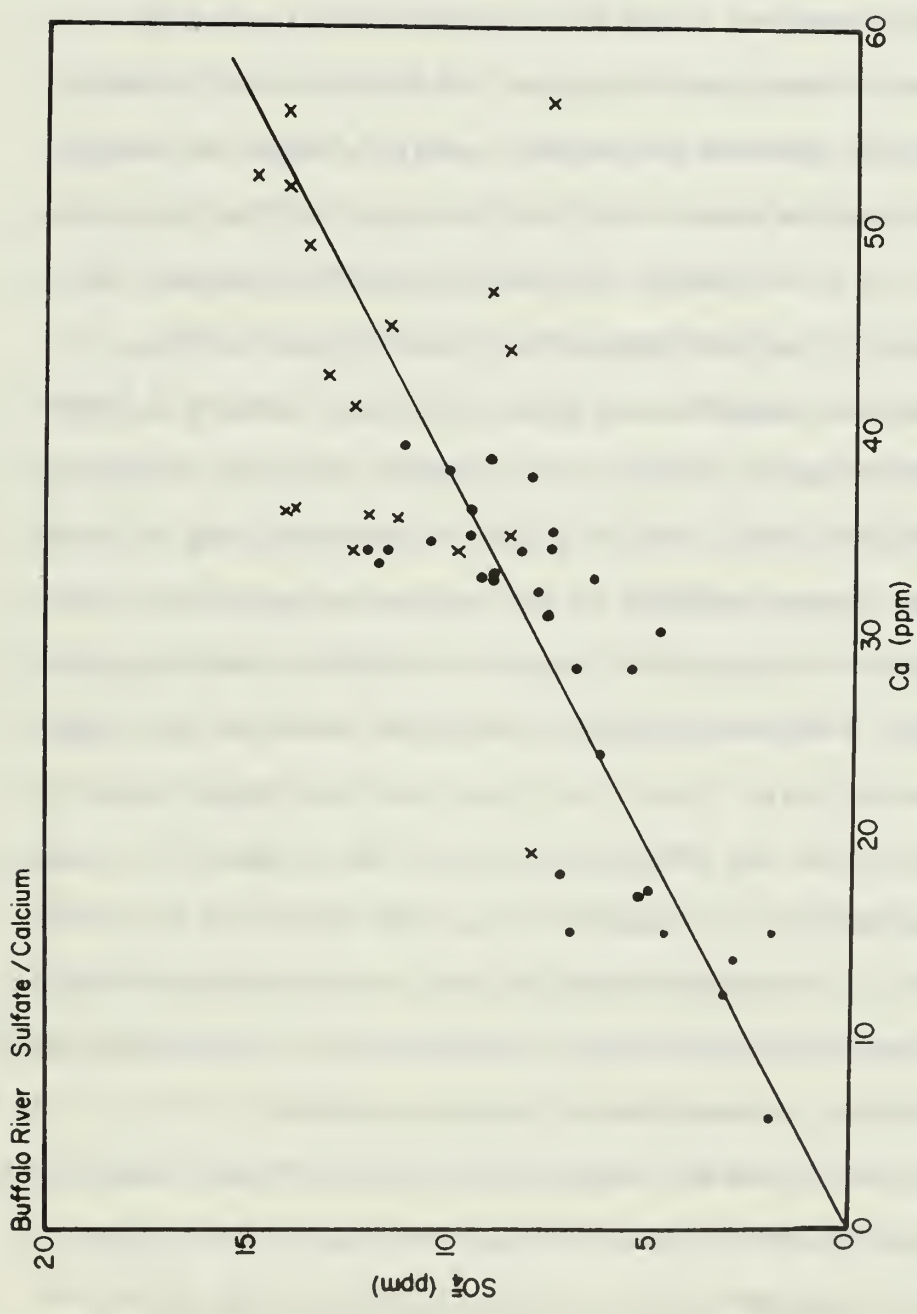


Figure 23
Sulfate Concentration versus Calcium Concentration for Mainstream and Tributaries of Buffalo River May 22 through May 27, 1973

mile 80 the concentration of magnesium in several tributaries was relatively low. The influx of low magnesium water may simply cause a dilution in this section of the river.

The values for specific conductance, alkalinity, calcium concentration, magnesium concentration, and sulfate concentration were generally higher for tributaries as compared to the mainstream of the river at the confluence of the tributary and the river. One explanation for this observation would be that the tributaries contain a higher percentage of ground water than the river. That is, the lower calcium, magnesium, etc. content of the river results from the dilution of tributary water with surface runoff. Further evidence for this is shown in Figure 22. A plot of the calcium concentration verses alkalinity shows a straight line for the data obtained from the mainstream of the river. However, data from tributaries show a line of greater slope indicating an enrichment in carbonate species relative to the calcium concentration. The one sample taken at a spring, 52-S, showed an alkalinity of 208 ppm and a 44 ppm calcium. This would indicate that ground water of this region is enriched in alkalinity. Thus it is likely that the higher values of alkalinity observed for the tributaries reflect the presence of a higher percentage of ground water as compared to the main stream of the river. The straight line relationship between calcium concentration and sulfate concentration indicate that the origin of sulfate is calcium sulfate which is present throughout the watershed of the Buffalo River.

Manganese values on all samples were below 0.05 ppm. However, the iron content ranged from less than 0.05 ppm to in excess of 1.0 ppm. The method used to measure iron, atomic absorption spectroscopy, is sensitive to both the iron present in solution as well as most forms of particulate iron. The use of an unfiltered and unacidified sample for

atomic absorption determination of iron probably reflects data somewhere between soluble iron and total iron since certain silicate species are probably incompletely disassociated in the flame.

As shown in Figure 14 the iron content of the samples taken from the mainstream of the river gradually decreased from river mile 138 through river mile 70. This trend is probably due to the gradual setting of suspended material which had been introduced into the stream by the rains on May 21 and May 22. High values observed after river mile 45 reflect the presence of suspended sediment introduced by the heavy rains on the evening of May 26 and morning of May 27.

With the exception of sample number 44, zinc concentrations ranged from less than 0.02 to 0.20 ppm. Deposits of zinc minerals occur in several locations throughout the Buffalo River watershed. Several deposits were mined during the period from 1940 through 1950. The presence of zinc in the water of the Buffalo River is to be expected. A more detailed investigation of zinc present in the river and its tributaries during a low flow condition could reveal interesting anomalies related to zinc deposits.

With the exception of sample number 44, nitrate and orthophosphate values are relatively low. It is difficult to determine the origin of phosphate and nitrates in the Buffalo River system. In addition to natural sources, these nutrients can originate from such sources as fertilizers or domestic or industrial effluents. Assuming that other elements necessary for production are present in a natural water system, concentrations of 0.10 ppm orthophosphate usually indicate adequate phosphorous for plankton production. Under some situations 0.10 ppm orthophosphate could be considered as high. The total phosphorous of the river system should be studied in order to evaluate the level of phosphorous present.

The response of the nitrate concentration to the influx of heavy runoff at river mile 45 is apparent. It is obvious that nitrate is introduced into the river during periods of excessive runoff.

Sample number 44 is clearly anomalous in several water quality parameters including zinc, phosphate, nitrate, potassium and sodium. This sample was taken immediately upstream from the Highway 65 bridge. The presence of relatively high concentrations of both phosphate and nitrate would suggest agricultural runoff as a source of these constituents. However, the high concentration of zinc in this sample is difficult to explain on the basis of agricultural runoff. Since only one sample was observed to have these high values, little significance can be placed on the results from a statistical standpoint. In order to determine if this observation is valid, further investigations of the river in the vicinity of Highway 65 should be conducted.

Values for sodium and potassium were erratic. A very slight downward trend in the sodium concentration between river mile number 138 and 55 may be present. If such a trend does exist, it may reflect the response of the river to the rains which had occurred earlier in the week. Anomalous values of sodium were observed during the period of excessive runoff on May 27.

The most striking feature of the chemistry of the Buffalo River system as determined from this investigation is the gradual increase in calcium, magnesium, and alkalinity in a downstream direction. Such data show clearly that the river continues to dissolve material from its sediments as it flows. During the period of this investigation the section of the river which was surveyed appeared to be free of organic loading which would cause low dissolved oxygen values. Tributaries were generally higher in some of the parameters measured which

probably reflects the presence of a higher percentage of ground water in the tributaries. One sample taken near Highway 65 contained relatively high concentrations of phosphate and nitrate. No suitable explanation can be given for this observation.

TABLE NUMBER 6

RESULTS OF ANALYSIS OF SAMPLES FROM BUFFALO RIVER

Sample Number	Temp. °C	D.O. ppm	pH	Sp. Cond. μ Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	F ppm	SO ₄ ppm	PO ₄ ppm	Alk ppm	NO ₃ ppm
1	18.0	8.6	7.0	45	7.6	1.1	5.4	1.0	0.7	0.0	0.04	1.5	0.13	<2.0	0.06	18	1.4
4	16.8	9.9	7.4	75	3.6	2.9	11.8	1.2	0.3	0.0	0.06	2.5	0.26	3.1	0.04	31	1.3
5	16.2	9.4	7.5	79	5.2	2.9	13.6	1.2	0.3	0.0	0.10	4.4	0.24	2.9	0.05	34	1.9
8	17.8	9.6	7.4	120	17.2	1.9	17.0	1.5	0.4	0.0	0.03	1.7	0.29	5.1	0.02	46	0.5
9	18.8	9.7	7.8	92	6.8	1.1	15.0	1.4	0.4	0.0	0.04	1.5	0.24	2.0	0.06	38	0.5
10	20.2	9.7	7.8	115	5.2	1.2	15.0	1.5	0.4	0.0	0.02	1.3	0.25	4.7	0.04	38	0.5
12	17.0	9.4	7.8	100	3.6	1.4	15.0	1.4	0.2	0.0	0.01	--	--	7.0	--	--	--
15	18.5	10.0	7.3	118	7.2	6.7	16.8	1.5	0.5	0.0	0.08	1.4	0.30	5.3	0.06	44	0.3
16	18.8	9.4	7.3	140	6.4	2.4	18.2	1.8	0.5	0.0	0.01	1.4	0.28	7.3	0.10	50	0.4
19	18.9	10.4	7.5	250	5.2	1.7	24.0	2.0	0.4	0.0	0.08	2.3	0.30	6.2	0.07	61	0.6
21	19.5	11.4	7.6	260	3.6	1.3	27.2	1.9	0.0	0.0	0.02	1.5	0.11	7.4	0.04	70	0.5
23	20.1	11.1	7.6	240	6.0	1.8	28.0	2.0	0.3	0.0	0.07	1.3	0.11	5.6	0.06	71	0.6
25	20.2	10.4	7.7	229	2.8	1.4	28.2	2.1	0.2	0.0	0.07	3.4	0.14	6.7	0.08	70	0.6
26	21.5	9.7	7.6	192	3.6	1.4	30.8	2.1	0.0	0.0	0.03	3.4	0.20	7.6	0.06	75	0.3
28	16.5	11.6	7.5	285	2.4	1.4	33.0	2.2	0.1	0.0	0.01	3.0	0.11	8.9	0.05	78	0.3
30	19.9	10.4	7.6	209	4.4	2.1	32.4	2.2	0.1	0.0	0.08	3.7	0.11	6.5	0.04	78	0.2
32	20.0	10.9	7.6	242	2.8	1.2	34.0	2.7	0.0	0.0	0.04	3.7	0.22	11.6	0.03	86	0.2

TABLE NUMBER 6 CONTINUED

Sample Number	Temp. °C	D.O. ppm	pH	Sp. Cond. μ Mhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	F ppm	SO ₄ ppm	PO ₄ ppm	Alk ppm	NO ₃ ppm
33	22.0	9.8	7.7	305	6.0	1.9	35.0	3.0	0.2	0.0	0.15	5.3	0.32	7.4	0.06	84	0.2
35	21.6	11.4	7.7	276	4.4	1.6	34.8	2.9	0.0	0.0	0.15	5.8	0.30	9.5	0.05	85	0.2
37	21.9	11.2	7.7	315	4.0	1.4	30.0	2.6	0.0	0.0	0.21	3.4	0.25	4.7	0.05	80	0.3
38	24.9	11.6	7.8	--	6.0	1.1	34.0	2.3	0.0	0.0	0.12	3.4	0.41	8.2	0.07	84	0.3
40	24.9	12.0	7.8	--	3.6	1.9	32.2	1.8	0.4	0.0	0.08	2.9	0.15	8.7	0.06	83	0.2
41	24.9	9.0	7.5	--	2.0	0.9	34.6	1.8	0.2	0.0	0.01	2.6	0.17	10.5	0.03	85	0.1
43	24.9	9.8	7.6	--	4.4	2.2	34.2	2.0	0.1	0.0	0.03	3.4	0.28	12.1	0.02	86	0.4
44	20.0	10.0	7.6	--	10.8	4.2	35.6	2.1	0.2	0.0	0.52	5.6	0.10	--	0.30	99	8.7
46	20.2	9.6	7.6	--	4.4	1.1	36.0	2.4	0.2	0.0	0.05	3.2	0.11	9.4	0.04	91	0.1
48	20.9	10.8	7.7	--	7.6	0.9	38.0	2.1	0.1	0.0	0.07	2.2	0.13	10.1	0.08	98	0.1
50	24.9	11.2	7.7	--	6.0	1.2	39.2	2.5	0.0	0.0	0.05	2.5	0.17	11.2	0.03	101	0.1
51	24.9	11.6	7.8	--	13.6	2.9	38.6	2.5	0.0	0.0	0.01	3.3	0.21	9.0	0.08	100	0.3
52	24.9	8.6	--	--	7.6	1.5	34.4	2.6	0.4	0.0	0.02	2.3	0.30	7.6	0.06	99	1.2
54	20.2	8.5	--	--	13.6	2.7	32.6	2.3	0.3	0.0	0.03	2.0	0.12	9.5	0.10	100	1.7
56	24.9	8.8	7.5	--	5.6	2.0	32.4	2.5	0.8	0.0	0.07	3.1	0.12	9.0	0.07	84	2.8
58	24.9	11.4	7.5	--	4.4	1.4	32.0	3.0	0.8	0.0	0.04	2.1	0.15	11.8	0.05	87	1.9
59	24.9	9.6	7.6	--	6.8	3.6	37.6	3.1	0.6	0.0	0.05	2.4	0.19	8.1	0.05	91	1.3

TABLE NUMBER 7
RESULTS OF ANALYSIS OF SAMPLES FROM TRIBUTARIES OF BUFFALO RIVER

Sample Number	Temp. °C	D.O. ppm	pH	Sp. Cond. μMhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	F ppm	SO ₄ ppm	PO ₄ ppm	Alk ppm	NO ₃ ppm
6	16.9	9.7	7.6	290	8.8	1.6	37.8	3.1	0.1	0.0	0.04	3.7	0.13	10.1	0.09	125	2.3
7	17.1	9.6	7.7	180	6.8	1.6	34.8	2.5	0.0	0.0	0.03	4.2	0.16	8.5	0.04	100	0.4
13	15.5	9.8	7.6	255	--	1.8	--	--	--	--	--	--	--	--	--	--	--
14	15.1	10.0	7.6	341	0.4	1.8	56.4	1.8	0.0	0.0	0.01	3.0	0.22	7.4	0.03	179	0.5
17	19.2	12.2	7.7	325	4.4	--	49.8	1.9	0.1	0.0	0.04	4.0	0.21	13.6	0.08	173	2.1
18	19.8	9.7	7.7	372	4.4	3.8	45.6	6.6	0.0	0.0	0.07	3.0	0.17	11.4	0.02	159	0.4
20	19.8	10.8	7.6	279	6.4	2.9	--	--	--	--	--	--	--	12.1	--	--	--
22	19.0	9.9	7.6	359	2.4	1.0	48.0	2.9	0.0	0.0	0.01	4.2	0.21	12.1	0.08	144	0.5
24	21.2	12.9	7.7	298	2.4	1.4	36.0	2.0	0.1	0.0	0.10	2.4	0.16	13.8	0.03	96	0.8
27	15.5	12.2	7.2	305	1.2	0.9	52.2	2.7	0.0	0.0	0.01	2.3	0.22	14.1	0.01	162	2.0
29	18.4	10.2	7.6	345	3.6	1.5	52.8	8.4	0.0	0.0	0.09	2.0	0.32	14.7	0.04	187	1.0
31	18.1	10.5	7.5	328	4.4	0.8	42.6	6.0	0.0	0.0	0.02	2.6	0.42	13.1	0.01	169	0.1
34	20.2	11.6	7.2	225	15.2	5.1	19.6	1.4	0.0	0.0	0.38	4.4	0.30	8.0	0.02	53	0.1
36	23.9	10.5	7.6	290	5.2	1.9	35.6	2.3	0.0	0.0	0.08	2.0	0.12	11.3	0.04	93	0.7
39	24.9	9.4	7.3	245	4.4	1.1	34.0	2.1	0.0	0.0	0.06	1.6	0.14	9.8	0.02	89	0.3
42	24.0	9.5	7.3	360	3.2	1.7	45.6	1.8	0.0	0.0	0.03	1.9	0.19	12.0	0.01	144	1.0
45	24.9	7.8	7.4	450	4.8	2.0	55.2	1.1	0.0	0.0	0.04	2.7	0.21	14.1	0.01	183	1.3

TABLE NUMBER 7 CONTINUED

Sample Number	Temp. °C	D.O. ppm	pH	Sp. Cond. μMhos	Na ppm	K ppm	Ca ppm	Mg ppm	Fe ppm	Mn ppm	Zn ppm	Cl ppm	F ppm	SO ₄ ppm	PO ₄ ppm	Alk ppm	NO ₃ ppm
49	24.9	9.6	7.8	408	2.0	1.1	46.2	8.6	0.0	0.0	0.01	2.0	0.24	14.1	0.02	173	0.3
52-S	24.9	9.0	7.2	473	10.0	3.1	44.4	13.6	0.0	0.0	0.11	5.8	0.20	8.4	0.02	208	1.2
53	24.9	11.4	--	360	2.8	1.3	41.4	5.4	0.1	0.0	0.06	1.8	0.17	12.4	0.05	147	1.3
55	24.9	11.6	7.6	380	2.8	1.3	46.8	2.5	0.0	0.0	0.04	2.1	0.22	8.9	0.01	158	1.3
57	24.9	10.2	7.5	249	2.4	1.3	33.6	2.5	0.2	0.0	0.04	1.2	0.20	12.4	0.04	94	1.6

TABLE NUMBER 8

Range and mean values of analysis of samples taken from the mainstream of the Buffalo River. Data for sample number 44 were excluded from these calculations.

PARAMETER	MINIMUM VALUE	MAXIMUM VALUE	MEAN VALUE
temperature (°C)	16.2	24.9	21.0
dissolved oxygen (ppm)	8.5	12.0	10.2
pH	7.0	7.8	7.6
specific conductance (μmhos)	45.0	315.0	184.0
sodium (ppm)	2.0	17.2	6.0
potassium (ppm)	0.9	6.7	2.0
calcium (ppm)	5.4	39.2	28.1
magnesium (ppm)	1.0	3.1	2.1
iron (ppm)	0.0	0.8	0.3
manganese (ppm)	0.0	0.0	0.0
zinc (ppm)	0.01	0.21	0.07
chloride (ppm)	1.3	5.8	2.8
fluoride (ppm)	0.10	0.41	0.21
sulfate (ppm)	2.0	12.1	7.3
phosphate, ortho (ppm)	0.04	0.30	0.06
alkalinity (ppm)	18.0	101.0	74.0
nitrate (ppm)	0.1	2.8	0.9

GEOCHEMICAL SEDIMENT ANALYSIS

(Funded by OWRR A-025-ARK)

Principal Invesgiterator: Dr. K. F. Steele

Sediment and water samples were collected at eight sites along the Buffalo and Little Buffalo Rivers, Arkansas (Fig. 1). These samples were analyzed for trace elements and the data are presented in Tables 9 and 10. The water data presented in Table 10 were provided by Dr. Joe Nix of Ouachita Baptist University (analysis by atomic absorption spectrometry).

The sediment samples were first air dried and then oven dried at 108°C for approximately three hours. After drying, the sediments are sieved on a -95 mesh nylon sieve. Several portions of selected samples were prepared by slightly different processes. Without exception all elements (Table 9) were more concentrated in the -95 mesh fraction than in the +95 mesh fraction. Powdering the sample had little or no effect on the heavy metal concentration but did increase Na and K. The latter is explainable by the opening of inclusions in the chert grains (dominant sediment) which are known to contain Na⁺ and K⁺.

Three acid treatments of the sediments were compared: (1) cold aqua regia for 13 hours, (2) cold concentrated hydrochloric acid for 13 hours, and (3) refluxing aqua regia for one hour. Cold aqua regia consistently yielded higher Cd than cold hydrochloric acid; however, the latter yielded 5-10% higher Fe extractions. Refluxing aqua regia for one hour consistently gave higher K, Cu, Fe, Cr and Ni concentrations than the cold aqua regia treatment; however, these increases were not substantial.

The treatment of one gram, unpowdered, -95 mesh samples with 2 ml of aqua regia for 13 hours is considered satisfactory as a routine method for examining these stream sediment samples for environmentally important element concentrations. Following the acid treatment, the sample is filtered

using No. 40 Whatman filter paper, diluted to 50 ml and analyzed using atomic absorption spectrometry. Suitable methods for analysis of U, As, and Hg are still under investigation.

Although additional data are needed for valid interpretation, the preliminary results (Table 9) suggest various trends and relationships. For example, Na, K, Fe, and Mn each exhibit a gradual decrease in concentration downstream, while Ca and Mg exhibit increases in concentration. There are higher concentrations of Co, Cr, Ni and Pb at station #1, and high Zn and Cd at station #8 (Fig. 1). Cu exhibits little variation. These trends are controlled by the geology along the river. The Na, K, Fe and Mn decreases in concentration and the Ca and Mg concentration increases are related to the change from a "sandstone" watershed to a "limestone" watershed. The higher Co, Cr, Ni and Pb concentrations are probably due to two factors: (1) the presence of shale grains in the sediments (shale usually has relatively high heavy metal concentrations), and (2) station #1 is near a known lead mineralized area (Ponca). The high Zn and Cd concentrations occur immediately downstream from the old zinc mining area of Rush.

Clays are present in small quantities in the sediment samples and thus are not a major sorber of the trace elements as expected. However, correlations between Co, Cu, Cr, Pb, Ni, and Mn each with Fe appear to be significant. A plot of Ni versus Fe is given in Figure 24 as an example. This indicates that iron (and manganese) oxides are the major sorber of the trace elements from the stream water. Zn and Cd show a diffuse relationship with hardness (hardness data - D. Parker, personal communication, 1973) indicating that these two element concentrations may be controlled to a large degree by carbonate equilibria.

It appears that it may be possible to predict the concentration of heavy metals in solution in these stream waters within at least several parts per billion on the basis of the sediment composition. The prediction may be

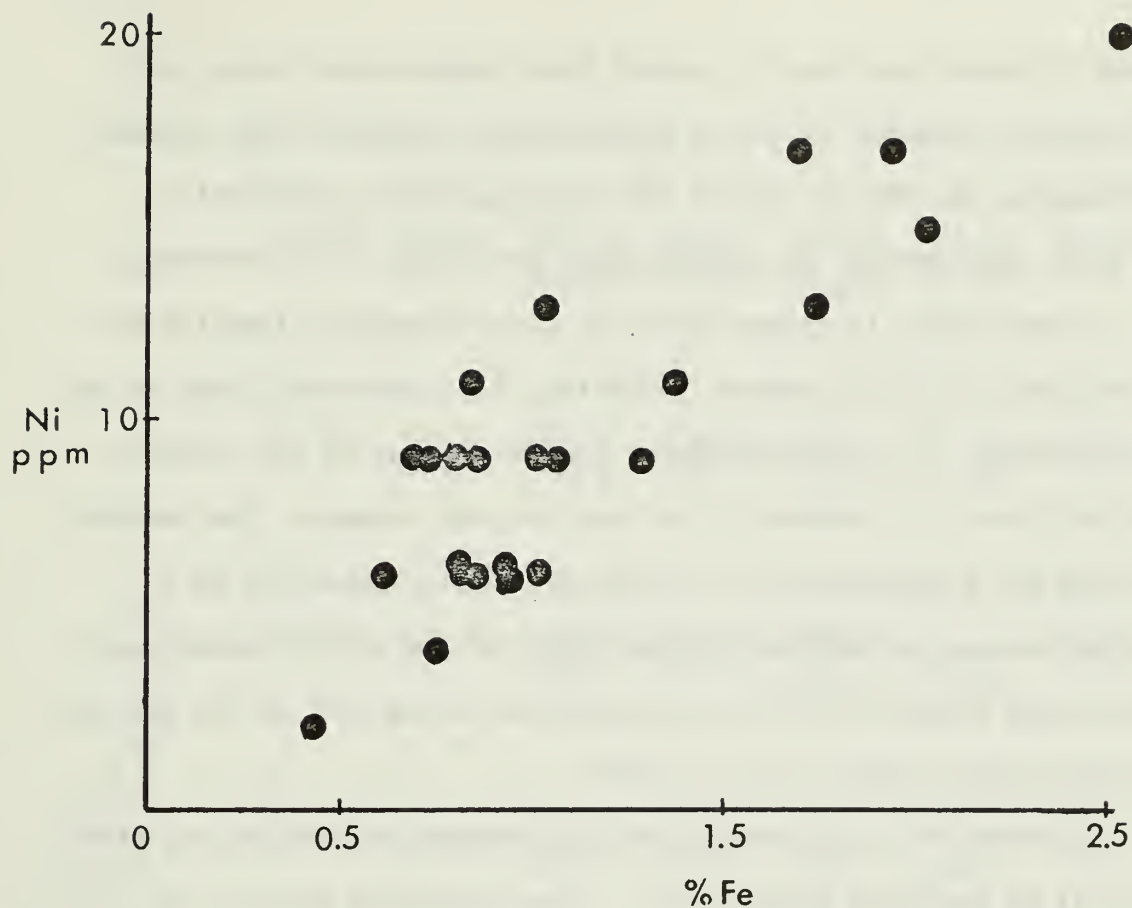


Figure 24. Concentration of Ni versus Fe in sediments

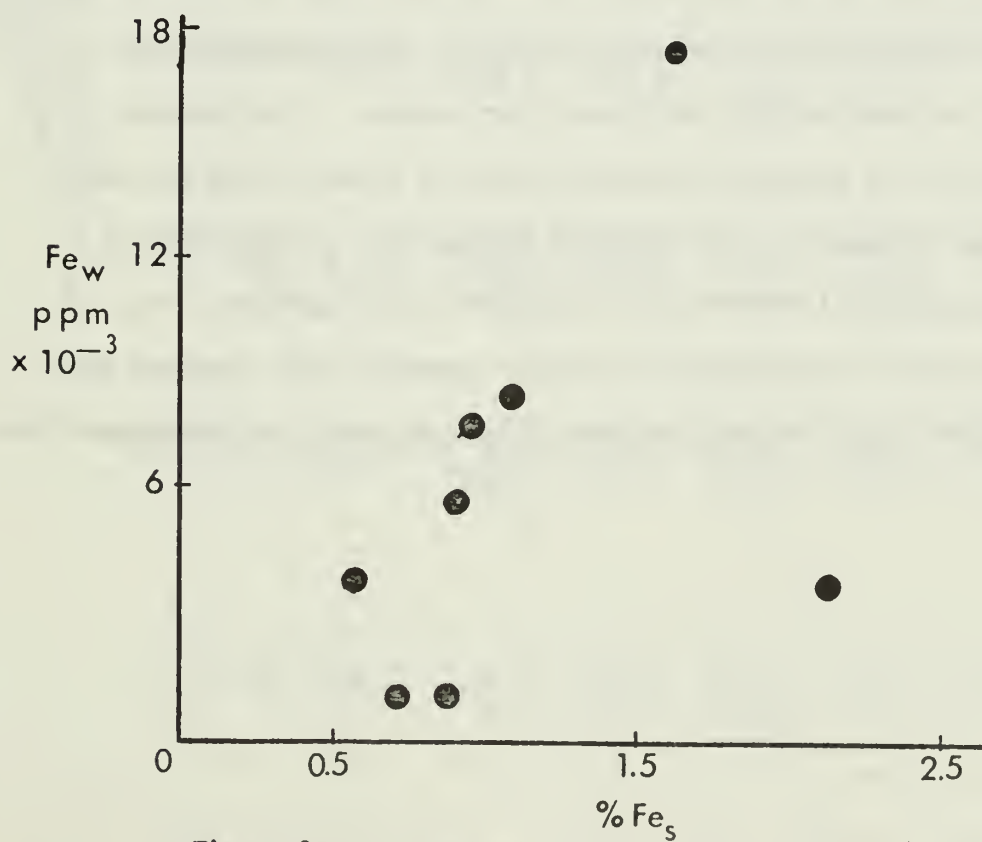


Figure 25. Concentration of Fe in water (Fe_w) versus Fe in sediments (Fe_s).

considerably better when based on annual water compositions since water compositions are expected to have a greater daily variation than sediment compositions. Fe, Mn, and Pb exhibit the most significant correlations between water and sediment concentrations. See Figure 25 as an example.

In conclusion, it appears that the river below Rush (station #8) is the only major site of possible pollution, i.e. anomalously high Zn and Cd concentrations. Cd is especially of concern because of its toxicity and the fact that it is stored in the flesh of some animals. The sediment compositions are a reflection of the geology. There appears to be a correlation between the sediment compositions and the water compositions; and iron oxides appear to be the major material taking part in the sorption of the heavy metals (except for Zn and Cd).

Monitoring the relationships of the sediment composition and other factors will be continued during FY 74. A more detailed study of the sediment chemical variations along the river will also be carried out. Future work should include chemical analysis of the suspended river sediment and its relationship with the river system. A preliminary investigation of the suspended sediments will be begun during the latter part of FY 74. Anomalous areas detected during this project such as the area near Rush will receive more intensive investigation. The sediment data will be correlated with other research data dealing with the Buffalo River such as land use maps, biologic data, and hydrologic data.

Table 9

Chemical Data
Buffalo River Sediments
(concentration-ppm except for Fe given in %)

	1	2	3	4	5	6	7	8
Na	A 9	0	0	0	23	0	0	0
	B 0	0	18	59	0	0	0	0
	C 136	127	227	49	0	9	45	0
K	A 186	163	278	204	198	158	154	138
	B 299	77	119	74	104	99	124	59
	C 184	99	164	124	92	74	97	87
Ca	A 605	1302	740	990	928	990	740	2115
	B 970	3380	1460	887	1670	2300	2725	7300
	C 640	13,700	2060	3040	843	2290	3400	6800
Mg	A 563	375	476	525	363	613	500	888
	B 750	313	313	2940	313	563	608	2050
	C 500	470	405	3880	250	936	625	1620
Fe	A 2.03	0.84	1.74	1.28	1.06	0.82	0.82	0.61
	B 2.53	1.01	1.37	0.95	1.01	0.75	0.94	0.44
	C 1.94	0.86	1.69	1.03	0.81	0.72	0.86	0.70
Co	A 1.3	0.3	0.9	0.7	0.4	0.4	0.4	0.4
	B 1.5	0.4	0.4	0.4	0.5	0.5	0.7	0.4
	C 0.7	0.7	0.6	0.6	0.7	0.6	0.7	0.6
Cr	A 7	3	9	5	6	3	5	5
	B 23	3	10	5	12	10	13	6
	C 18	12	13	3	12	10	6	7

Table 9 continued

Ni	A	15	6	13	9	9	6	6	5
	B	20	6	11	6	9	4	6	2
	C	17	11	17	13	9	9	9	9
Cu	A	6	3	6	4	4	2	3	3
	B	9	2	4	2	3	3	4	3
	C	6	3	5	5	3	3	3	3
Zn	A	70	42	79	48	42	67	92	343
	B	58	58	58	49	54	113	79	430
	C	58	76	78	58	33	104	87	350
Cd	A	0.9	0.1	0.5	0.3	0.3	0.6	0.6	2.2
	B	1.7	1.5	1.5	1.3	0.0	1.7	0.5	5.0
	C	1.3	0.9	1.4	0.7	0.9	0.9	1.3	3.3
Pb	A	11	4	9	7	7	8	7	6
	B	15	7	10	5	6	6	8	6
	C	9	8	17	11	5	4	6	6

A - Collection Trip - May 22-23

B - Collection Trip - June 9

C - Collection Trip - June 24

Numerals refer to sample stations in Figure 1

Table 10 continued

	1	2	3	4	5	6	7	8
Ag	A	0.001	0.000	0.001	0.000	0.002	0.001	0.000
	B	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0005
	C	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
Cd	A	--	--	--	--	--	--	--
	B	0.0050	0.0020	0.0095	0.0030	0.0050	0.0045	0.0045
	C	0.0030	0.0025	0.0045	0.0035	0.0030	0.0070	0.0030

Numerals and letters are defined in Table 1

SPECIAL BIOLOGICAL PARAMETERS -- PHYCOLOGICAL REPORT

Principal Investigator: Dr. R. L. Meyer

The floating algae were sampled for this portion of a preliminary survey of the Buffalo River. Sample collection was simultaneous with water sampling for other physical and chemical parameters. Sample sites have been indicated on Figure 1.

The samples were collected by holding a 15 cm diameter 25 mesh net in the current from 1 to 2 minutes. The contents were washed into 30 mls vials containing 0.5 mls M_3 fixative. The preserved organisms were identified with the aid of a Zeiss Photoscope II containing phase-contrast and Nomarski interference optics.

The composition of the algal flora was recorded at the generic level with a composite sample retained for specific determination. The abundances were subjectively determined by ranking the organisms into four categories. Dominant organisms are reported as "abundant" with secondary dominants listed as "common". Those genera with few representative are ranked as "uncommon" while those with single representatives as "rare". Thus the data given in Table 11 present both qualitative and quantitative aspects of the float in algae population. In addition, those genera marked with an asterisks contain euplanktonic species while the unmarked genera are typically epiphytic, epilithic or epipellic.

The data in Table II are arranged by major taxonomic categories. Five of the thirteen classes of freshwater algae were observed. The Chlorophyceae or green algae are represented by two colonial forms and four filamentous types. Ahkistrodesmus and Pediastrum are euplanktonic colonial forms. Pediastrum was observed only once in the first survey while two colonies of Ankistrodesmus were found at different stations

Table 11 Qualitative and Quantitative Distribution of Floating Algae

GENUS	Survey 1								Survey 2								Survey 3							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Chlorophyceae																								
Ankistrodesmus*																					r			
Pediastrum*	r																				r			
Ulothrix								c																r
Stigeoclonium								c																r
Oedogonium								u																r
Cladophora								c																
Conjugatophyceae																								
Spirogyra	r							r																u
Zygnema																								c
Mougeotia								c																c
Cosmarium*																								u
Closterium*																								r
Staurodesmus*																								r
Bacillariophyceae*																								
Melosira*	u	c						u																a
Fragilaria*	a	a						a																c
Synedra*	a	a						a																a
Cocconeis								a																a
Navicula	a	a						a																a
Cymbella	a	a						a																a
Epithemia								a																a
Gomphonema								a																a
Nitzschia	c	c						a																r
Cyanophyceae																								
Oscillatoria*	r							c																r
Lyngbya								c																
Haploisiphon																								
Rivuluria																								r
Rhodophyceae																								
Batrachospermum																								

*Genera with euplanktonic species **a - abundant u - uncommon
 c - common r - rare

in the third survey. The filamentous Chlorophyceae, Ulothrix, Stigeoclonium, Oedogonium and Cladophora, were erratically observed throughout the collecting period. These filamentous green algae are typically attached to rocks, soil or vegetation. Their uneven occurrence may be related to stream use patterns. The organism may have become dislodged by canoers or other persons using the river.

The presence of attached, filamentous forms of the Conjugatophyceae, Spirogyra, Zygnema and Mougeotia, in the net plankton probably indicates active use of the stream. The unicellular genera, Cosmarium, Closterium and Staurodesmus, though quite rare, are true planktonic organisms.

The most abundant organisms were the diatoms or Bacillariophyceae. Species of Synedra, Navicula and Cymbella were dominant at most stations during each survey. Melosira, Fragilaria and Nitzaschia are less abundant though widely distributed along the river and are present throughout the summer. Cocconeis, an epiphytic diatom, is dependent upon the distribution of filamentous green algae. Thus its distribution parallels the occurrence of Stigeoclonium, Oedogonium, Cladophora and filamentous Conjugatophyceae. Attached species of Gomphonema and Epithemia were uncommon to rare.

The Cyanophyceae or blue-green algae have a limited distribution with very reduced numbers. Haplosiphon was observed only once during the earliest survey. Two small clusters of the attenuated blue-green trichomes of Rivuluria appeared in the lower sampling stations during the last survey. The simple trichomes of Oscillatoria occurred occasionally in the first and last survey except at Station 8 in May. Oscillatoria, as well as Lyngbya were common at the first survey's last station. Lyngbya was observed once again at Station 3 during the second survey. The Cyanophyceae are apparently of minor importance in the summer algal flora.

The rare red or Rhodophyceae algae Batrachospermum was present at Stations 4 and 7 during the mid-summer survey. Reproductive stages were noted. This genus is usually tenaciously attached to stones in rapidly running cold water, thus their appearance in net samples suggests dislodgement by various stream use activities.

Most of the sampling stations contain similar algal floras except for station 8. The populations are usually dominated by diatoms with an occasional occurrence of other organisms. Station 8, however, consistently contained filamentous green algae from the Chlorophyceae and/or Conjugatophyceae. The diatom Cocconeis is associated with these genera.

The algae identified from the Buffalo River from Boxley to Rush are included within 26 genera. The genera are distributed into 5 classes with 9 genera of Bacillariophyceae, 6 genera in both the Chlorophyceae and Conjugatophyceae, 4 genera of Cyanophyceae and a single genus of Rhodophyceae. The Bacillariophyceae contains not only the largest number of genera but also species and the greatest abundance of organisms. In certain instances however, the greatest mass is produced by the filamentous algae; i.e. the green algae at Station 8 during the first two surveys, also Batrachospermum at Station 4 and 7 in the second survey.

Future phycological research on the Buffalo should describe the role of the total floating algal mass. It will be necessary, however, to distinguish between the euplankton and the chance plankton or tychoplankton. Each type of phytoplankton occupies a specific niche and makes a particular contribution to the ecosystem. The source and abundance of the tychoplankton must be accounted for whenever the plankton of the river is examined. Conversely, the loss of epipellic, epiphytic and epilithic algae is important in the understanding of the dynamics of the ecology of these attached forms. Thus the two major communities,

the free floating and the attached, are closely interrelated and future research on either community should consider the interactions with the alternate community.

BOTTOM FAUNA DESCRIPTION

BOTTOM FAUNA DESCRIPTION

(Funded by OWRR A-025-ARK)

Principal Investigator: Dr. Eugene H. Schmitz

Introduction

Several recent investigations of lotic systems have tended to be directed toward the ecology of free-flowing streams prior to impoundment. Among these are the exhaustive treatment of Doe Run, Kentucky by Minckley [7], and a study of the bottom organisms of the White River Basin by Aggus and Warren [8]. Other efforts have been oriented toward various aspects of pollution and the management of streams for sport and commercial fisheries. Gaufin and Tarzwell [9] concluded that little reliance can be placed upon the mere occurrence of a single species in a given locality, and that very few definite statements can be safely made concerning the indicator values of specific organisms. At the same time, however, Gaufin and Tarzwell noted that "...definite conclusions can be formulated as to the value of certain associations of populations or populations of aquatic invertebrates for indicating the severity and extent of pollution and the degree of stream recovery..." More recently, Gislason [10] has compared species diversity of benthic macroinvertebrate communities in Michigan streams subject to four levels of human perturbation during an annual cycle and the effects of the different levels on community structure. Thus, a vast literature dealing with lotic ecology exists, but a comprehensive historical review is not attempted in this report. Rather, selected efforts are noted to indicate general trends and areas of focus.

The purpose of the present report is to contribute to our knowledge of the Buffalo National River, Arkansas by way of a qualitative survey of shallow-water benthic macroinvertebrates during a period extending from 22 May 1973 through 25 June 1973.

Acknowledgements

I am indebted to Research Assistant Paul D. Kittle without whose able, enthusiastic, and conscientious efforts both in the field and laboratory this investigation could not have been completed within the allotted time. The willing assistance of Dr. David A. Becker, Messrs. Edgar D. Short and Robert R. Kraemer in the field is gratefully acknowledged. This part of the overall project was supported by WRRRC Contract A-025-ARK.

Qualitative Methods:--Organisms were taken from eight selected sampling stations along the Buffalo National River from Boxley, Arkansas to Rush, Arkansas (Figure 1) on three occasions during the period 22 May 1973 through 25 June 1973. Specific sampling dates were 22-23 May, 14-15 June, and 24-25 June 1973. Care was taken, insofar as possible, to sample both a riffle and a shallow pool habitat at each station. Specimens were taken by hand-picking from submerged stones and rubble, by hand-netting, and by disturbing the substrate in front of a hand dip net with the opening facing upstream. Adult insects were taken from vegetation adjacent to each sampling site using a sweep net. Smaller specimens were killed and fixed in 70% ethyl alcohol, and larger specimens (e.g. crayfishes and bivalves) were preserved in 5% formalin. Samples thus prepared were transported back to the laboratory where specimens were identified and sorted according to taxonomic categories and sampling locations. Numbers of individuals taken during qualitative collecting are recorded for reference purposes only (Appendices A, B, C). While such numbers may be roughly indicative of general availability in terms of procedures utilized, they should not be interpreted as indices of relative abundance.

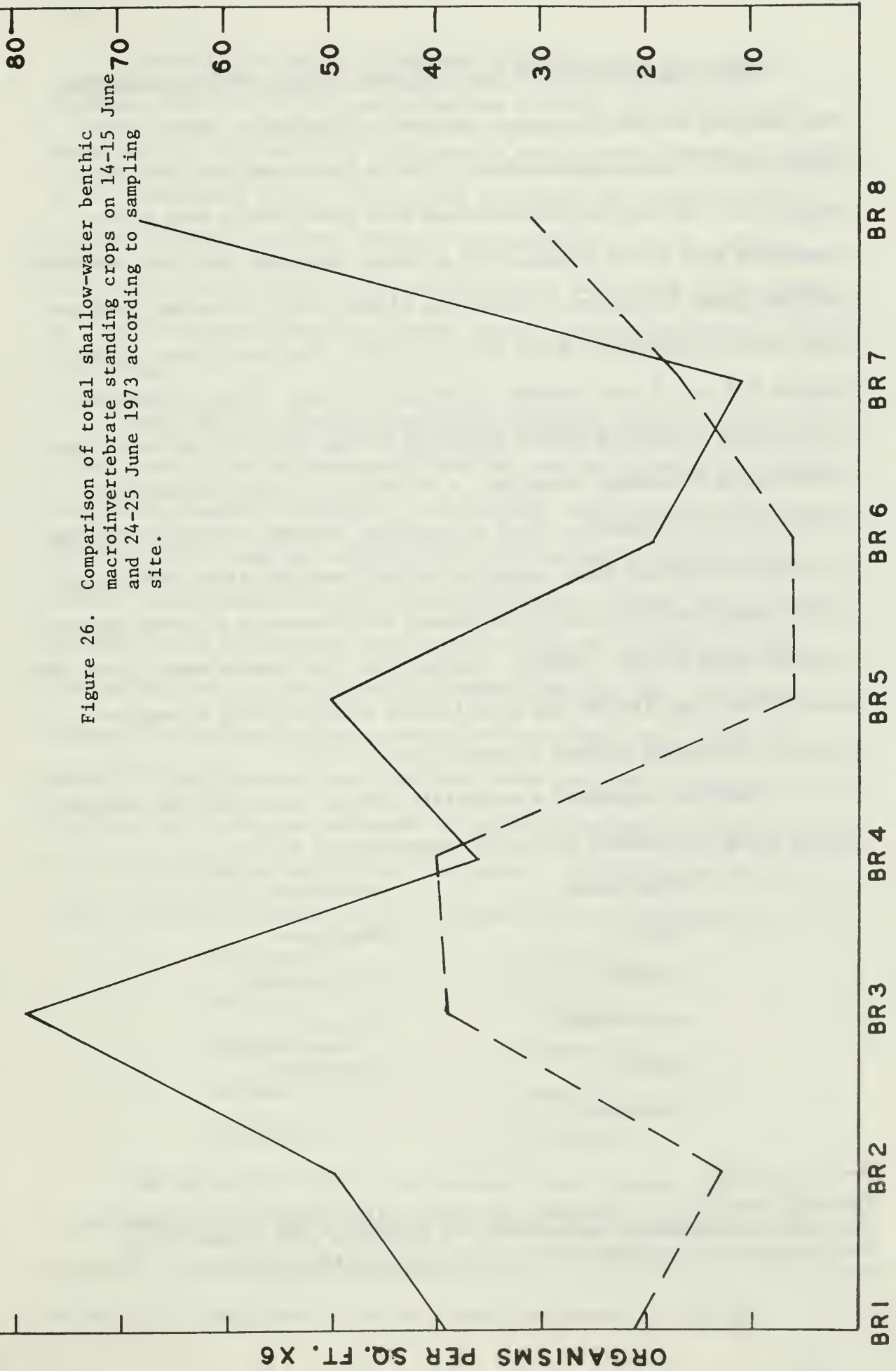
Quantitative Methods:--Quantitative sampling was conducted with a Surber square-foot stream bottom sampler. The rocky nature of the bottom which prevailed in the shallow water areas of all sampling sites prevented the use of "grab" type samplers (e.g. Peterson and Eckman dredges), a situation virtually identical to that encountered by Aggus and Warren^[8] in their pre-impoundment survey of the White River Basin.

Quantitative samples were taken by forcing the square-foot frame of the sampler into the substrate with the opening of the net facing upstream. While holding the sampler in place, organisms were dislodged within the square-foot frame by washing the stones and subsequently stirring the finer gravel and silt. The extreme paucity of benthic macroinvertebrates (presumably due to the scouring effects of flooding) made it necessary to discard quantitative procedures during the 22-23 May sampling period. During the two subsequent periods, it was found necessary to pool the contents of six square-foot samples taken at each station in order to obtain statistically adequate samples (Figure 26.) Even so, with the exception of certain Ephemeroptera, most samples so taken were adequate only in terms of the standing crops of organisms collectively representing most major taxa and total standing crops (Figure 26; Table 13). Specimens and debris concentrated in the blind end of the sampler net were separated manually with forceps in a white enamel sorting pan, and preserved in 70% ethyl alcohol. In the laboratory, the organisms were sorted according to major taxon and sampling site, identified, and counted.

Results and Discussion

For convenience, results as they pertain to each sampling site are discussed. General observations, statements, and comments follow.

Figure 26. Comparison of total shallow-water benthic macroinvertebrate standing crops on 14-15 June and 24-25 June 1973 according to sampling site.



BR-1--Buffalo River at State Highway Bridge, Boxley, Arkansas.

This sampling station represents the general headwaters region of the Buffalo River, being approximately 10 miles downstream from its origin (Figure 1). The site is characterized by a broad riffle area on the downstream side of the bridge, with a rather extensive pool area extending upstream under the bridge. During the 23 May visit, the water level was high, but not bank-full; murky but not muddy. The water level probably dropped 1.5 to 2.0 feet between 23 May and 25 June, This circumstance necessitated collecting nearer midstream during June in areas which were inaccessible by wading during May, a variable in stream limnology that is difficult to reconcile. Such a situation, whereby the May collecting area dried up by mid-June, prevailed for all sampling sites with exposed riffle areas, and will not be reiterated in discussions of other sampling stations which follow. However, during June, the lowered water level made possible both qualitative and quantitative sampling along a complete transect of exposed riffles at most sites.

This site supported a moderately diverse fauna with the following groups being represented (Table 12; Appendices A, B, C):

Oligochaeta	Coleoptera
Isopoda	*Neuroptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Gastropoda
Plecoptera	

*Although Pennak [11] separates the Dobson flies (Megaloptera) from the lacewings (Neuroptera), the priority of including both groups within the Neuroptera is recognized for the purpose of this report.

Ephemeroptera were the dominant organisms both in terms of abundance (80% and 74% of total organisms recorded on 15 and 25 June, respectively) and diversity; eight mayfly genera were represented (Table 12, 13; Appendices D, E). This is the only sampling site from which Lirceus (Isopoda) was taken (Table 12; Appendices A, B, C). Since much of this habitat often dries up during the hot months of the summer, it is quite probable that the isopods are of subterranean and/or upstream pool origin.

BR-2--Buffalo River at Confluence with Mill Creek. This site is located about 18 miles downstream from BR-1 and is accessible by hiking from Shaddox Cemetery (Figure 1). During May, the relatively high water level precluded sampling anywhere except the stream's periphery and a limited riffle area at the Mill Creek confluence. During June, however, the water level had receded sufficiently to expose two shallow riffle areas within about a 50-yard stretch downstream from the confluence. Because this site has no quiet pools, and since only deep rapids and exposed riffles characterized this site, both qualitative and quantitative sampling procedures were conducted at regular intervals downstream within about 50 yards beginning with the confluence. The following groups of benthic macroinvertebrates were represented (Table 12; Appendices A, B, C):

Oligochaeta	Coleoptera
Decapoda	Neuroptera
Ephemeroptera	Trichoptera
Odonata	Diptera
Plecoptera	Gastropoda

The Ephemeroptera were represented by nine genera, although it should be noted that the Coleoptera and Trichoptera presented a greater diversity than BR-1, being represented by seven and five genera, respectively. The Mill Creek confluence is an interesting situation in that the

temperature of Mill Creek is much colder (spring-fed?) than the Buffalo River. A virtual abrupt shearing plane exists for about 20 feet downstream from the confluence, and this "plane" seems to act as a life zone boundary for most benthic macroinvertebrates inhabiting this site. Practically none of the forms taken at this site were found in the colder water originating from Mill Creek (the temperature differential across this "plane" was not recorded. Noteworthy is the fact that two adults of Epeorus were taken from vegetation adjacent to this site; nymphs, however, were not taken and presumably exist further upstream in the colder waters of Mill Creek, for Berner [12] notes that nymphs "... live in shallow, cool or cold, rapidly flowing water, where they are attached to rocks sticks, or other firmly anchored material..." That Epeorus lives most of its life cycle in and around Mill Creek is further substantiated by the fact that neither nymphs nor adults were taken from any other sampling site.

Ephemeroptera were the dominant organisms in terms of abundance (77% and 42% of total organisms taken on 14 and 24 June, respectively), although Diptera (families Tipulidae, Chironomidae, and Simuliidae) were moderately abundant on 25 June (24%) (Table 13; Appendices D, E).

Some camping activity and evidence of heavy machine gravel excavation were noted immediately upstream from the Mill Creek confluence on 25 June.

BR-3--State Highway 7 Bridge at Jasper, Arkansas. This site is on the Little Buffalo River about nine miles upstream from its confluence with the "big" Buffalo River (Figure 1). The area presented exposed riffle and pool zones about 25 yards upstream from under the bridge, and was the most productive of benthic macroinvertebrates with the following groups represented (Figure 26; Tables 12, 13; Appendices A, B, C, D, E):

Decapoda	Neuroptera
Ephemeroptera	Trichoptera
Odonata	Diptera
Plecoptera	Gastropoda
Coleoptera	

Except for the Ephemeroptera (12 genera), other major groups displayed no greater diversity than BR-1 and BR-2; no genera occurred exclusively at this site, with the exception of Tropisternus (Coleoptera) and Chimarra (Trichoptera) (Table 12; Appendices A, B, C). All "adults at lights" noted in Table 12 were taken from around the lights of the Riverview Motel immediately adjacent to BR-3 and are considered to have originated from the Little Buffalo River.

As previously noted, BR-3 was the most productive site during the sampling period (Figure 26). Ephemeroptera were the dominant forms, representing 53% of all organisms taken on 25 June (Table 13; Appendices D, E). It may be noted that crayfishes (Decapoda) were quite common, and that this is the only site at which Decapoda were taken during quantitative sampling procedures.

We are informed by way of conversation with Jasper citizens that the town has no sewage treatment facility, that most private residences and business houses utilize septic systems, but that at least three establishments (one motel, one laundromat, and the county jail) discharge raw sewage into the Little Buffalo River upstream from BR-3. If indeed there is a greater nutrient input because of this situation, the relatively greater benthic productivity cannot be directly correlated on the basis of this brief investigation.

BR-4--Low-water Bridge at Hasty, Arkansas. This site actually is located about two miles south of Hasty and about seven miles downstream from BR-2 (Figure 1). The sampling area includes rather extensive exposed riffles,

pools, and a gravel bar on the immediate downstream side of the low-water bridge. There was some evidence of human activity, including recreation and gravel excavation. Representatives of the following groups of benthic macroinvertebrates were recorded for this station (Table 12; Appendices A, B, C):

Decapoda	Neuroptera
Ephemeroptera	Trichoptera
Odonata	Diptera
Plecoptera	Gastropoda
Coleoptera	Pelecypoda

Ephemeroptera displayed the greatest diversity, being represented by 11 genera. This is the only site from which Brachyptera (Plecoptera), Promoresia, and Cyrnellus (Trichoptera) were taken (Table 12; Appendices A, B, C). Further, it was the only area for which living Pelecypoda were recorded on 23 May--from an isolated pool formed by an uprooted tree.

Ephemeroptera were dominant on 15 June, constituting 68% of all benthic macroinvertebrates present. However, on 24 June, a decline, although not very significant, in total productivity was noted (Figure 26; Table 13, Appendices D, E). This was due partially to a significant decline (64%) in the mayfly nymph (Ephemeroptera) population during this period. On 24 June, the Coleoptera were dominant (34%), and the Ephemeroptera were sub-dominant (27%) (Table 13). Exuviae of late instar ephemeropteran nymphs were observed on exposed stones in the riffles and on the stream periphery, indicating that an emergence of a mayfly generation had occurred during the period 15-24 June.

BR-5--Gravel Bar and Launch Area at Gilbert, Arkansas. This site is located about 20 miles downstream from BR-4, and is exposed to considerable recreational use (Figure 1). The area is composed of an extensive gravel bar, which at relatively low water levels only presents accessible exposed

riffle zones and pool areas at its upstream extremity. Careful qualitative sampling yielded almost no benthic macroinvertebrates on 22 May, presumably due in part to the scouring effect of rising water levels immediately prior to and during our visit on this date; even so, considering the various adaptations of stream invertebrates taken at other stations, the seeming near sterility of this location on 22 May is extremely difficult to account for. Perhaps the areas at the upstream extremity of the gravel bar (accessible only on 14 and 24 June) present a greater variety of microhabitats and niches than the exposed riffles and deep rapids immediately adjacent to the gravel bar during higher water levels. The following major groups were represented during the June sampling periods (Table 12; Appendices A, B, C):

Hirudinea	Coleoptera
Isopoda	Neuroptera
Decapoda	Trichoptera
Ephemeroptera	Diptera
Odonata	Gastropoda
Plecoptera	Pelecypoda

The Ephemeroptera were represented by six genera, and this is the only location for which Centroptilium was recorded, and then only from a quantitative sample (Table 12; Appendices A, B, C, D, E). Perlesta and Cheumatopsyche were the only genera representing the Plecoptera and Trichoptera, respectively. Further, Hirudinea and Asellus (Isopoda) were taken from this site only. The extensive gravel bar area exposed during the summer months again suggests a possible subterranean origin for the occurrence of isopods, although as in the case of BR-1, there is a deep pool immediately upstream from which these creatures may migrate or be carried during high water levels. Isopods as a group are poorly adapted

for clinging to submerged surfaces, do not swim, and while they occur frequently in stream systems throughout the United States, are limited for the most part to the quieter regions of streams and to lentic habitats.

The absence of Ephemeroptera nymphs from the quantitative sample on 14 June is difficult to reconcile, although numerous exuviae observed on exposed stones in the riffles suggested that an emergence of adults occurred prior to this date. Moreover, the great majority taken on 24 June were early instar nymphs. Only three groups, the Plecoptera, Gastropoda and Pelecypoda, were represented in the quantitative sample of 14 June (Table 13; Appendices D, E). Perhaps because of the absence of Ephemeroptera and Diptera on 14 June, this location showed the greatest increase in benthic productivity during the 14-24 June period, for on the latter date, the Ephemeroptera were the dominant organisms (37%) with the Diptera being sub-dominant (18%).

BR-6--Buffalo River Fishing Resort and Boat Launch Area at State Highway 14 Bridge. This site is located about 15 miles downstream from BR-5. It is an area which experiences some concentrated human recreational activity, since it is a commercially operated fishing resort. At normal to low water levels, the launch is a small gravel bar adjacent to a relatively wide shallow to deep rapids zone on the immediate downstream side of the Highway 14 bridge. Specimens representing the following groups of benthic macroinvertebrates were taken (Table 12; Appendices A, B, C):

Oligochaeta	Plecoptera
Decapoda	Coleoptera
Ephemeroptera	Trichoptera
Odonata	Diptera

With the exception of a relatively quiet zone beneath overhanging adjacent vegetation and a shallow adjacent pool, the wide, swift-moving rapids make for a relatively monotonous habitat complex. Although many

of the Ephemeroptera (represented by nine genera) are well-adapted for swift-water habitats, a poor overall benthic fauna in terms of diversity and abundance might well be expected. The Ephemeroptera, then, were the dominant organisms, constituting 63% and 72% of the total standing crop on 14 and 24 June, respectively (Table 13). BR-6 was the least productive of all locations, averaging 2.2 organisms per square foot for the 14-24 June period (Figure 26; Table 13).

BR-7--Buffalo River State Park, Arkansas. The only area reasonably accessible by foot and with equipment was a gravel-sand beach zone adjacent to a heavily used camp ground and upstream from a new tertiary sewage treatment plant. This portion of the river is subjected to concentrated recreational activity. The stream bed is deep and the water relatively fast-flowing, so that sampling efforts had to be restricted to the periphery; quantitative procedures involved sampling in shallow water at regular intervals adjacent to the shore along a 25-yard stretch. With the exception of a small riffle under an overhanging clump of small trees, and a small shallow bay formed by a gravel-sand spit, the bottom environment was monotonous; even so, the two exceptions mentioned were characterized by essentially the same type of substrate. Representatives of the following major taxa were taken (Table 12, Appendices A, B, C):

Decapoda	Neuroptera
Ephemeroptera	Trichoptera
Plecoptera	Diptera
Coleoptera	Gastropoda

Presumably, a variety of Ephemeroptera (nine genera) and Coleoptera (10 genera) are adapted for this kind of habitat. Moreover, this is the only site for which Brachycercus (Ephemeroptera; in a quantitative sample), Hydrovatus, Enochrus (Coleoptera), and Chauloides (Neuroptera) were recorded

(Table 12; Appendices A, B, C). Nevertheless, this area was among the poorest in terms of total benthic productivity, averaging 2.4 organisms per square foot for the period 14-24 June; a decline of 40% was noted for this period, which may be attributed in part to an emergence of Ephemeroptera prior to 24 June (Table 12, Appendices D, E).

BR-8--Buffalo River at Confluence with Clabber Creek (Clabber Creek Shoals). This station is located about six miles downstream from BR-7 and about two miles south of Rush, Arkansas (Figure 1). The sampling site selected was an area of rapids and limited exposed riffles in a curve of the river receiving water from an extensive pool about one-half mile long; Clabber Creek enters the Buffalo River at this curve, and immediately upstream from the sampling site. The land from which the site is accessible is an extensive gravel-scrub area owned by Mr. Fred Dirst. Mr. Dirst operates a boat launch and canoe rental business, and human use of the area for recreational purposes appeared moderate. The sampling site presented a variety of microhabitats for benthic macroinvertebrates, and representatives of the following groups were recorded (Table 12, Appendices A, B, C):

Decapoda	Neuroptera
Ephemeroptera	Trichoptera
Odonata	Diptera
Plecoptera	Gastropoda
Coleoptera	Pelecypoda

The Ephemeroptera were the most diverse organisms being represented by seven genera, although the Diptera were quite diverse as well with several unidentified species in three families being recorded (Table 12, Appendices A, B, C).

Because the rapids became quite deep and swift near mid-stream,

quantitative sampling represents only about one-half of a complete transect for this station. Ephemeroptera were dominant, averaging 5.2 organisms per square foot for the 14-24 June period. No other group was clearly sub-dominant, although the Plecoptera, Trichoptera, and Diptera averaged 1.3, 0.8, and 0.8 organisms per square foot, respectively, for the same period. In terms of total organisms, *BR-8 was the most productive area, averaging 8.3 organisms per square foot (Table 13, Appendices D, E); an increase of 53% was noted for the 14-24 June period, primarily attributable to mayfly (Ephemeroptera) production (Figure 26, Table 13; Appendices D, E).

General Observations, Comments, and Miscellanea

The extremely low benthic productivity of the Buffalo River is especially striking when compared to average figures ranging from 188 to 966 organisms per square foot reported for spring-fed streams, intermittent streams and large tributaries of the White River Basin by Aggus and Warren^[8]. As in the present study, their procedures were limited to riffles and shallow pools. Many benthic macroinvertebrates occupy an important link in the aquatic food chain, especially in the diet of game fishes, and one wonders how fish populations--if indeed substantial populations exist--survive in the Buffalo River. It must be remembered, however, that the present brief investigation was conducted during and immediately after the scouring effects of frequent flooding and fluctuating water levels. Even so, the apparent degree of colonization and rate of recovery at the end of the sampling period was much lower than might be reasonably expected for similar streams. Perhaps areas not sampled, or conceivably the substrates of extensive deep pools, sustain a substantial level of benthic productivity.

*Refers to the Buffalo River proper; does not include its tributary, the Little Buffalo River, which averaged 9.8 organisms per square foot.

With certain exceptions previously noted, Ephemeroptera were the dominant organisms both in terms of diversity and abundance, a situation which might be expected, particularly in consideration of the time of year selected for this brief investigation. Funk^[13] reported that Ephemeroptera were the dominant organisms in the Black River, Missouri. Sublette^[14] stated that Hydropsyche (Trichoptera) constituted the dominant group of riffle organisms in Clear Creek, Washington County, Arkansas. More recently, Aggus and Warren^[8] observed that the dominant number of organisms in both riffles and pools were Diptera (mostly Chironomidae).

Although several species of Odonata adults were observed and some taken at most stations, the striking paucity of nymphs among the benthic macroinvertebrate fauna is difficult to reconcile. Pennak^[11] notes that "...The naiads are commonly found on submerged vegetation and the bottoms of ponds, marshes, streams, and in the shallows of lakes, but are rare in polluted waters..." The adults, having strong powers of flight, may well have spent the aquatic phases of their life cycle in areas some considerable distance removed from the site of observation.

There is no evidence to support the tempting speculation that human perturbation has contributed to the extremely low levels of benthic productivity which characterized BR-6 and BR-7. More likely, the monotony of their environments offers a minimum of microhabitats and niches for colonization by benthic macroinvertebrate communities.

Table 12

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
Oligochaeta								
Lumbriculidae?	X	X			X	X		
Hirudinea								
Isopoda					X			
Asellus	X							
Lirceus								
Decapoda								
Orconectes (male)	X	X	X	X	X		X	X
Unident. females	X	X	X	X	X			X
Unident. juveniles		X	X			X		
Ephemeroptera								
Isonychia	X	X	X	X		X	X	X
Baetis	X	X	X	X	X	X	X	
Pseudocloeon	X	X	X	X	X			X
Epeorus ? (adult)		X		X	X	X	X	X
Heptagenia	X	X		X	X	X	X	X
Rhithrogena		X	X	X	X	X	X	X
Stenonema	X	X	X	X	X	X	X	
Choroterpes		X	X	X			X	
adults			X					
Habrophlebiodes	X		X				X	
Paraleptophlebia	X		X	X			X	
Ephemerella	X	X	X	X		X	X	
Tricorythodes			X	X		X		
Caenis		X		X	X			
Potamanthus			X			X	X	
Ephoron						X		X
Odonata								
Hetaerina (adult)		X						
Unident. adult	X	X	X					
Argia (nymph)			X	X	X	X		
Argia (adult)		X	X		X			X

Table 12. Qualitative distribution of shallow-water benthic macroinvertebrates at selected sampling sites on the Buffalo National River (X = present).

Table 12--continued

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
Plecoptera								
<u>Brachyptera</u> ?				X				
<u>Acroneuria</u> (nymph)		X	X	X		X		X
adults at lights			X					
<u>Neoperla</u>				X				
<u>Perlesta</u> (nymph)	X	X	X	X	X	X	X	X
adult	X	X						
adults at lights			X					
Perlodidae								
unident. adult		X						
<u>Isoperla</u>	X		X					
<u>Hastoperia</u>	X							
Coleoptera								
<u>Hydrovatus</u> (adult)							X	
<u>Dineutus</u> (adult)		X					X	
<u>Berosus</u> (adult)							X	X
<u>Cymbiodyta</u> (adult)						X	X	
<u>Enochrus</u> (adult)							X	
<u>Tropisternus</u> (adult)			X					
<u>Helichus</u> (adult)						X	X	
<u>Lutrochus</u> (adult)		X		X	X	X	X	
<u>Ectopria</u> (larva)		X				X		
<u>Psephenus</u> (larva)	X	X	X			X		X
adult	X	X	X	X	X			
Elmidae								
unident. larva	X	X		X			X	
<u>Promoresia</u> ? (adult)				X				
<u>Stenelmis</u> (adult)		X	X	X	X	X	X	X
Neuroptera								
<u>Chauliodes</u>							X	
<u>Corydalus</u> (larva)	X	X		X				X
adults at lights			X					

Table 12--continued

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
<u>Trichoptera</u>								
unident. pupa	X	X	X					
<u>Chimarra (larva)</u>		X		X				X
adults at lights			X					
<u>Cynnellus ? (larva)</u>				X				
unident. adults at lights			X					
<u>Cheumatopsyche</u>	X	X	X	X	X	X	X	X
<u>Hydropsyche</u>		X				X	X	X
<u>Helicopsyche</u>		X	X					
<u>Diptera</u>								
Tipulidae ?	X		X					
Tipulidae		X						
Chironomidae (larva)	X	X	X	X		X	X	X
pupa						X		
Simuliidae	X	X		X	X	X	X	X
Gastropoda	X	X	X	X	X	X	X	X
Pelecypoda				X	X			X
*Ephemeroptera								
<u>Centroptilum</u>					X			
<u>Brachycercus</u>						X		
*Odonata								
Gomphidae								X

*Taken only in quantitative samples.

Table 13

	BR-1	BR-2	BR-3	BR-4	BR-5	BR-6	BR-7	BR-8
	6/15	6/25	6/15	6/25	6/15	6/24	6/14	6/14
OLIGOCHAETA						0.5		
ISOPODA	0.3				0.2			
DECAPODA			0.8	0.3				
EFEMEROPTERA	2.8	4.8	1.7	3.5	4.5	7.0	4.5	1.6
PLECOPTERA			0.2	0.5	0.2	0.6	0.5	1.0
COLEOPTERA			1.2	0.2	0.2	2.0	0.3	0.2
NEUROPTERA			0.2			0.3		0.2
TRICHOPTERA	0.2	1.0	0.8	3.3	0.5	0.7	0.7	0.5
DIPTERA	0.2	0.7	0.3	2.0	1.0	1.5	0.8	0.8
GASTROPODA			0.2	0.8		0.5	0.7	0.2
PELECYFODA					0.2	0.3		
ODONATA								0.2
TOTAL (ORGANISMS/FT ²)	3.5	6.5	2.2	8.4	6.5	13.1	6.6	5.9

Table 13. Standing crops of major taxa represented during 14-15 June and 24-25 June 1973 sampling periods (organisms/ft²).

VEGETATION AND SITE CHARACTERISTICS

VEGETATION AND SITE CHARACTERISTICS

Principal Investigator: Dr. E. E. Dale, Jr.

Introduction

General information about the natural features of the Buffalo River region has been known for many years, but only one quantitative ecological study of vegetation and soils has been made. Read^[15] presents a correlation of occurrence of tree species with underlying rocks and soils in the Koen Experimental Forest located near Jasper, Arkansas, but information concerning vegetation along the river or on uplands in other areas of the Buffalo River basin is not included.

The primary objective of this study was to make a preliminary investigation of vegetation types present and soil conditions at selected sites on the Buffalo River in support of water quality and other investigations.

Methods

Field work was conducted on May 22 and May 23, 1973 at study sites indicated in Figure 1. Each site was visited and observations were recorded as to forest and other vegetation types present, the general characteristics of these forest types, the effect of man's activities in these sites, and potential problems relating to use of the sites. Also, soil samples were collected and analyzed by the Soil Testing and Research Laboratory, Agronomy Department, University of Arkansas, and photographs (colored slides) were taken at each site. Finally, recommendations were made concerning potential public use of these sites on the basis of the information collected.

Summary

The vegetation community types of the selected sites are essentially similar in principal species present as in the types reported elsewhere in the Arkansas Ozarks [16, 17, 18, 19, and 20]. Also, the relative occurrence of the various vegetation types along a wet to dry moisture gradient, general habitat conditions, and soil factors in corresponding plant community types are similar.

A summary of forest vegetation types observed at the selected sites and surrounding areas is presented in Table 14 and the results of the soil analyses made from soils collected in the various sites are shown in Table 15.

The streamside and floodplain forest types (Table 14) on all sites have been modified by man in varying degrees. Also, they usually occur as isolated narrow strips near the river. The upland forest types have been less modified, but all such forests observed showed evidence of previous logging or grazing with the possible exception of some of the very steep slopes on high bluffs adjacent to the river. Minimal disturbance appeared to be in glade types located on steep slopes with soils derived from limestone or dolomite.

The non-forested areas on all sites were formerly cultivated fields in various stages of succession or were meadows or pastures. Vegetation of these areas consisted mostly of typical old field species of grasses and weeds or grasses commonly planted in pastures such as fescue or bermuda. No prairies were observed, although the open spaces of most glades supported some prairie grasses and wildflowers.

Some of the most important potential problems on all sites include; 1) pollution from areas within the basin but outside the National River Area boundaries, 2) flooding, and 3) overuse of the area by visitors.

The Buffalo National River, as all stream ecosystems, can be disrupted more easily by pollution than other types of areas because any pollutant introduced into the watershed can be transported to areas downstream.

Periodic flooding is a normal occurrence along the lower part of most river ecosystems. Since many recreation activities are centered on the river, any facilities such as buildings, campgrounds, etc. should not be constructed in areas subjected to flooding.

Overuse by visitors is perhaps the most serious threat to the river ecosystem since public use is an important potential source of pollution. Also, access to the river is frequently limited, and these access points will be subjected to exceptionally heavy use. This can destroy vegetation, cause soil erosion, and degrade the natural environment in other ways.

The foregoing discussion applies to all sites, but each individual site has different conditions and problems applicable to it. These conditions are summarized below.

Site 1 - Boxley

Forest vegetation has been cleared from most of this site except for a narrow fringe of streamside and floodplain forest near the river. The adjacent uplands are dominated by upland oak types (Table 14) or mixed oak and hickory. Land on the east side of the river within the site is being used as pasture, and that on the south side as a hay field composed mostly meadow fescue. This area is low and flat, and most of the site is subject to flooding.

The river at this point is too small or shallow for use by fishermen or for swimming and it cannot be floated by canoeists during much of the year.

A potential source of pollution is by cattle from a nearby farm. The recreational potential of the river is limited because of its small size at this site, which would make the area of limited value for development centered on activities related to the river.

Site 2 - Shaddox

The area next to the river is one of the most attractive sites examined. High bluffs are present on the north bank of the river and a large cleared area slopes gently toward the river on the south side.

The forest has not been removed next to the river or on the overlooking bluffs and adjacent uplands. Disturbance by man has occurred, but the streamside and floodplain forest type present provide shade and pleasant surroundings. The uplands on the south side of the river support second-growth oak-hickory forest. No serious sources of pollution were noted in the immediate area, but there is a possibility that stream pollution from Dogpatch Recreational Park could occur. The site could be used satisfactorily as a public use area, but potential recreational uses of the river would be minimal because of its small size and low flow during much of the year.

Site 3 - Jasper

This site on the Little Buffalo does not appear to be a good public use area centered on recreational activities related to the river because of the small amount of water during much of the year, the potential sources of pollution from the town of Jasper, traffic over the bridge across the site, and the fact that the native vegetation has been mostly removed or severely disturbed. A few streamside and lowland forest trees occur along the banks at this site. Most of the remainder of the area in the site is being used as pasture or is occupied by houses or commercial buildings.

Wooded areas downstream from the site have a better potential for development as public use areas.

Site 4 - Hasty

The site near Hasty appears to be one of the least disturbed sites near the river, the most isolated, and perhaps the most suitable for development. The water is generally shallow but with some fairly deep pools in part of the site. The stream bed is the widest here of all sites examined, with broad gravel bars between channel areas. Access to both sides of the stream is available by a low water bridge useable at all times except during periods of exceptionally high water.

The gravel bars support a typical growth of willow, cottonwood, and other streamside species. Fringes of floodplain and mixed lowland forests occur on both banks. These forests grade into oak types on the adjacent uplands, with a glade type occurring on drier places with soils derived from limestone or dolomite.

Cleared areas that appear to have been cultivated at one time are present on the south bank. These areas are dominated by grasses typical of old fields and pastures. These areas are located above the flood levels and are suitable for development.

Potential sources of pollution appear to be minimal in this area. One problem that seems to be developing is the destruction of cottonwood and other streamside tree species by beavers. The beavers were reintroduced into this area several years ago, but because of their destructive effects, they have been removed from the protected list of animals by the Arkansas Game and Fish Commission.

Site 5 - Gilbert

This site slopes gently southward immediately below the town of Gilbert. The upper part of the slope is an abandoned field in an early stage of plant succession dominated by broomsedge (Andropogon virginicus) and pasture grasses such as fescue and bermuda. A fringe of floodplain forest occurs at the edge of the field that extends down to the river. A broad gravel bar about 200 yards long and about 30 yards wide is present on the south part of the stream bed. This bar supports a dense forest of willows on the downstream portion of the bar.

The south bank is characterized by a steep bluff supporting narrow bands of streamside and lowland forest types near the river which grade into upland oak types on the higher portions of the bluff. A glade type is present in this area also.

The streamside and lowland forest types are fairly typical as to tree species present, but the understory has been greatly altered through the activities of man.

The large gravel bar affords excellent access to the flowing water which makes the site excellent for water-related recreation, but access to the river is limited presently to a narrow dirt and gravel road from Gilbert to the River. This road is impassible for automobiles (except 4 wheel drive vehicles) during wet weather. Overall, this area is an excellent site for future development.

The only important potential problem noted is pollution from the town of Gilbert.

Site 6 - Bridge Area Near Highway 14

A tourist court and fishing camp occupy this broad, flat, cleared area on the south side of the river. The edge of this area slopes abruptly down to the river and supports a typical narrow band of streamside and

lowland forest types. The north bank supports stream side species near the water, a narrow bank of lowland forest, and upland oak and glade types on the steep north bank.

This is a good camping area and suitable for further development as such. Access to the river is fairly easy at this site. Potential problems are pollution from cattle and dwellings nearby, and the noise created by traffic moving across the highway bridge.

Site 7 - State Park

The Buffalo River State Park area includes some of the best examples of vegetation on the Buffalo River basin. All plant community types listed in Table 14 are present, occurring along the same general moisture gradient as elsewhere in the Ozarks.

The vegetation of this area has received protection for many years, although much vegetation has been removed as the area was developed or damaged through heavy visitor use.

This area has been developed by the State and offers excellent recreational facilities applicable to use of the river. However, it is possible that changes may be needed in the developed areas to meet Park Service Standards. Perhaps the most serious present and future problem of this area is visitor overuse.

Site 8 - Rush

This site located between Rush and Clabber Creeks has been used for recreation for many years. A large cleared area is present between the uplands away from the river and the narrow fringe of mixed lowland and streamside forest types that occupies the steep alluvial bank next to the river.

This cleared area is the site of a former mill or factory building and scattered summer cottages or trailers. The area supports various pasture grasses and weeds.

The lowland and streamside forests have been subjected to some disturbance, but are among the least disturbed forests of these types observed at any site. The surrounding uplands, including the high bluff across the river from the site are dominated by the usual oak types.

The river bed has large gravel bars with scattered willow forests on them, and a large volume of water is present in the river channel. This, with the large cleared area on the high bank above the river makes the site an excellent area for camping and water-related recreational activities.

There are several problems at this site. One is that the road into the area that parallels Rush Creek is subject to flooding by Rush Creek. Another is the fact that much of the site is on deep alluvial soil that erodes easily when vegetation cover is removed as might occur in development of the area or through heavy visitor use. A third potential problem is pollution from nearby dwellings and perhaps from the abandoned mines upstream.

TABLE 14
Principal Forest Communities of the
Buffalo National River Area at
Selected Sites

Forest community types and principal species in each type observed in selected study sites on the Buffalo National River. The community types are listed in approximate order along a wet to dry moisture gradient.

GRAVEL BAR TYPE

<u>Common Name</u>	<u>Scientific Name</u>
Trees	
Black willow	<u>Salix nigra</u>
Ward's willow	<u>Salix caroliniana</u> var. <u>wardii</u>
Shrubs	
Witch hazel	<u>Hamamelis virginiana</u>
Herbs	
Smartweed	<u>Polygonum</u> spp.
Water willow	<u>Jussiaea leptocarpa</u>
Rush	<u>Juncus</u> sp.

STREAMSIDE TYPE

Trees	
Sycamore	<u>Platanus occidentalis</u>
Black river birch	<u>Betula nigra</u>
Silver leaf maple	<u>Acer saccharinum</u>
Cottonwood	<u>Populus deltoides</u>
Black willow	<u>Salix nigra</u>
Shrubs	
Buttonbush	<u>Cephalanthus occidentalis</u>
Herbs	
Cane	<u>Arundinaria gigantea</u>

(Herbaceous species composition highly variable)

Common NameScientific Name

FLOODPLAIN TYPE

Trees

Silver leaf maple
American elm
Green ash
Sweet gum
Box elder

Acer saccharinum
Ulmus americana
Fraxinum pennsylvanica
Liquidambar styracoflua
Acer negundo

Herbs

Virginia wild rye
Stinging nettle
Cane

Elymus virginicus
Laportea canadensis
Arundinaria gigantea

MIXED LOWLAND TYPE

Trees

Box elder
Green ash
American elm
Hackberry
Bitternut hickory
Red bud

Acer negundo
Fraxinus pennsylvanica
Ulmus americana
Celtis laevigata
Carya cordiformis
Cercis canadensis

Herbs

Herbaceous herbs species composition highly variable

Shrubs

Buckbrush
Spicebush

Symphorocarpus orbiculatus
Lindera bezoin

UPLAND TYPES

WHITE OAK TYPE

Trees

White oak
Mockernut hickory
Northern red oak
Black Hickory
Red maple
Serviceberry

Quercus alba
Carya tomentosa
Quercus borealis
Carya texana
Acer rubrum
Amalanchier arborea

Shrubs and Vines

Buckbrush
Dryland blueberry
Virginia creeper

Symphorocarpus orbiculatus
Vaccinium vacillans
Parthenocissus quinquefolia

Common NameScientific Name

Herbs

Beggerweed
Richweed
Hog peanut

Desmodium spp.
Pilea pumila
Amphicarpa bracteata

BLACK OAK TYPE

Trees

Black oak
White oak
Post oak
Mockernut hickory
Black hickory

Quercus velutina
Quercus alba
Quercus stellata
Carya tomentosa
Carya texana

Shrubs and Vines

Dryland blueberry
Sweet sumac
Virginia creeper
Wild grape

Vaccinium vacillans
Rhus aromatica
Parthenocissus quinquefolia
Vitis cordifolia

Herbs

Beggerweed
Poverty oat grass
Panic grass
Hog peanut
Goldenrod
Aster

Desmodium spp.
Danthonia spicata
Panicum spp.
Amphicarpa bracteata
Solidago spp.
Aster spp.

SOUTHERN RED OAK TYPE

Trees

Southern red oak
Black oak
Post oak
Mockernut hickory
Black hickory
Flowering dogwood

Quercus falcata
Quercus velutina
Quercus stellata
Carya tomentosa
Carya texana
Cornus florida

Shrubs and Vines

Virginia creeper
Dryland blueberry
Deerberry

Parthenocissus quinquefolia
Vaccinium vacillans
Vaccinium stamineum

Common NameScientific Name

Herbs

Beggerweed
 Poverty oak grass
 Panic grass
 Goldenrod
 Perfoliate aster
 Stiff sunflower
 Rabbit tobacco

Desmodium spp.
Danthonia spicata
Panicum spp.
Solidago spp.
Aster patens
Helianthus divaricatus
Antennaria plantaginifolia

POST OAK TYPE

Trees

Post oak
 Black oak
 Blackjack oak
 Mockernut hickory
 Southern red oak
 Black hickory
 Winged elm

Quercus stellata
Quercus velutina
Quercus marilandica
Carya tomentosa
Quercus falcata
Carya texana
Ulmus alata

Shrubs

Dryland blueberry
 Buckbrush
 Deerberry
 Sweet sumac

Vaccinium vacillans
Symphorocarpus orbiculatus
Vaccinium staminium
Rhus aromatica

Herbs

Beggerweed
 Fall panic grass
 Poverty oat grass
 Rabbit tobacco
 Goldenrod
 Stiff sunflower

Desmodium Spp.
Panicum lanuginosum
Danthonia spicata
Antennaria plantaginifolia
Solidago spp.
Helianthus divaricatus

PINE-HARDWOOD TYPE

Trees

Shortleaf pine
 White oak
 Black oak
 Black hickory
 Red maple
 Flowering dogwood
 Winged elm
 Sparkleberry

Pinus echinata
Quercus alba
Quercus velutina
Carya texana
Acer rubrum
Cornus florida
Ulmus alata
Vaccinium arborium

Common NameScientific Name

Shrubs and Vines

Dryland blueberry
Poison ivy
Buckbrush
Virginia creeper

Vaccinium vacillans
Rhus toxicodendron
Symphorocarpus orbiculatus
Parthenocissus quinquefolia

Herbs

Beggerweed
Poverty oat grass
Panic grass
Rabbit tobacco
Aster
Goldenrod

Desmodium sp.
Danthonia spicata
Panicum sp.
Antennaria plantaginifolia
Aster spp.
Solidago spp.

GLADE TYPE

Trees

Red Cedar
Post oak
Black oak
Blackjack oak
Winged elm
Persimmon
Sparkleberry

Juniperus virginiana
Quercus stellata
Quercus velutina
Quercus marilandica
Ulmus alata
Diospyros virginiana
Vaccinium arborium

Shrubs and Vines

Sumac
Greenbrier
Sweet sumac

Rhus copallina
Smilax bona-nox
Rhus aromatica

Herbs

Little bluestem
Beggerweed
Panic grass
Rabbit tobacco
Goldenrod
Aster

Andropogon scoparius
Desmodium canescens
Panicum sp.
Antennaria plantaginifolia
Solidago spp.
Aster spp.

Results from Soil Analyses. Samples collected May 22 and 23, 1973. Organic matter is listed as percent and mineral content in pounds/acre.

Soil Tests

Site	Habitat	pH	% O.M.	lbs/A P	lbs/A K	lbs/A Ca	lbs/A Na	lbs/A Mg	Cond. ECx10 ³
Streamside		7.8	0.70	24	35	1650	80	70	.10
Black oak Southern red oak		7.1	2.76	23	100	1950	80	160	.10
Mixed Lowland		7.5	1.71	39	145	1750	75	115	.10
Mixed Lowland		7.2	3.50	56	225	3000	80	200	.10
Post Oak Black Oak		7.8	4.00 ⁺	60	180	6600	90	265	.12
Floodplain		8.4	3.80	28	200	6400	80	160	.15
Floodplain		8.2	2.40	16	95	3650	80	120	.14
Abandoned Field		6.5	1.91	25	65	800	70	85	.10
Floodplain		8.2	1.81	39	130	2400	90	185	.10
Gravel Bar		8.6	2.28	24	65	3500	80	110	.10
Streamside		6.4	3.32	41	100	2600	80	190	.10
Streamside		7.7	1.15	12	55	1925	80	115	.10
Abandoned Field		6.3	1.81	46	115	725	90	115	.10
Streamside		8.8	1.12	11	40	3100	80	70	.10

SUMMARY

The objective to obtain "base-line" water quality data for the Buffalo National River has been accomplished. The data are of a reconnaissance nature and more information is needed before final conclusions and recommendations should be made; however, the following preliminary observation should have future significance:

1. The high dissolved oxygen and low total organic carbon concentrations at all stations indicate that there should be little trouble with oxygen depletion and low dissolved oxygen concentration in the river. Organic loading appears minimal.
2. High coliform organism concentrations at some locations in the river indicate the possible presence of fecal contamination. The possible presence of contamination indicates that the river water should not be used for drinking purposes without treatment and that the discharge of human waste should be closely regulated in the river valley.
3. The chemistry of the Buffalo River system appears to be dominated by the rock strata through which it flows. Calcium, magnesium and alkalinity gradually increases in the downstream direction.
4. The influence of groundwater in tributary streams is shown by values for specific conductance, alkalinity, calcium concentration, magnesium concentration, and sulfate concentration which were generally higher for tributaries as compared to their mainstream confluences.

5. Nitrate and orthophosphate values are relatively low (Figures 20 and 21); however data provided in Figures 2 and 3 suggest a general increase in concentration downstream. This apparent discrepancy may be related to the two different techniques used for the water analyses. Those data presented in Figures 2 and 3 were obtained using field analysis methods whereas the information illustrated in Figures 20 and 21 was obtained from laboratory analysis after storing the samples approximately one week. Although the laboratory analysis should provide a more accurate technique, sample storage may decrease the overall sensitivity of this method. Future sampling methodology will attempt to define this data anomaly. We would suggest additional funding to mount a spectrophotometer, power supply, and portable laboratory in a canoe. Such an arrangement would provide more precise determinations of nitrate and orthophosphate.
6. With reference to trace metals in sediments, the river below Rush contains anomalously high concentrations of Zn and Cd.
7. In some areas there appears to be a good correlation between sediment composition and water chemistry, and it may be possible to predict the concentration of heavy metals in solution on the basis of sediment composition.
8. Benthic faunal productivity is relatively low as compared with other free-flowing streams; however, this may be related to the frequent scouring effects characteristic of the Buffalo, particularly at the time when this study was conducted. The extremely low benthic productivity at BR-6 and BR-7 may be related to the lack of micro-habitats and niches for colonization rather than human perturbation.

9. The forest vegetation types observed at selected sample sites are essentially similar in principal species present as in the types reported elsewhere in the Arkansas Ozarks.

FUTURE RESEARCH AND MONITORING PROGRAM

A comprehensive study and monitoring program for the Buffalo National River has been submitted to the National Park Service. Our proposed five-year program includes four phases:

- I. This phase of the study and monitoring program will consist of basic data gathering for determining the water quality baseline, and establishing permanent bench marks for long-term water quality monitoring.
- II. Phase II will consist of data collection and analysis of those parameters influencing water quality, and understanding the relationship between these parameters and the Buffalo National River ecosystem.
- III. Assessment of the Buffalo National River's archaeological and historical resources.
- IV. Determination of reliable data sets which will indicate long-term trends and overall changes in water quality and ecosystems; and their applicability for remote sensing monitoring.

All basic data will be made compatible with the IBM-360 Computer.

Some of the general considerations given to the long-term monitoring program will include:

- 1) Specific present and future needs of the National Park Service relative to quantity, quality, locations, and chronology.
- 2) Available resources (funds and manpower).
- 3) Legal requirements.
- 4) Available technology (including on-site digital systems and remote sensing).
- 5) Operational costs.

This comprehensive proposal is structured around the tentative list of priorities established during the meeting with National Park Service personnel on 3 May 1973. The priorities were defined as follows:

Priority

- 1) Water Quality Surveying and Monitoring Program
- 2) Carrying Capacity of the Buffalo National River and Impact Study for the Proposed Camp Sites
- 3) Remote Sensing Monitoring
- 4) Vegetative Analysis
- 5) Ichthyofauna (Fish)
- 6) Ecological Parameters as Dictated by Geological Environment
- 7) Faunal Distribution
- 8) Archaeological and Historical Resources

PRIORITY	Reconn. Study FY 73	FY 74	FY 75	FY 76	FY 77	FY 78
Priority #1 Water Quality Surveying and Monitoring						
A) Physical and Chemical Characteristics	_____	_____	_____	_____	_____	_____
B) Heavy Metals Analysis	_____	_____	_____	_____	_____	_____
C) Geochemical Sediment Analysis	_____	_____	_____	_____	_____	_____
D) Phycological Research	_____	_____	_____	_____	_____	_____
Priority #2 Carry Capacity and Camp Site Impact Study						
A) Carrying Capacity		_____	_____	_____		
B) Camp Site Impact Study		_____	_____	_____		
Priority #3 Remote Sensing Monitoring						
A) Airborne	_____		_____	_____	_____	_____
B) Ground-based			_____	_____	_____	_____
Priority #4 Vegetation Study		_____	_____	_____		
Priority #5 Ichthyofauna (Fish)		_____	_____	_____	_____	
Priority #6 Ecological and Hydrological Parameters						
A) Ecological			_____	_____	_____	
B) Hydrological						
Priority #7 Faunal Distribution				_____	_____	_____
Priority #8 Archaeological and Historical Resources						
A) Archaeological				_____	_____	_____
B) Historical				_____	_____	_____

FUTURE PRIORITY MODIFICATIONS AS INDICATED
BY THE PRELIMINARY RECONNAISSANCE WATER QUALITY SURVEY

- 1) Apparent discrepancies in nitrate and orthophosphate measurements should be defined. Funding should be considered for mounting a spectrophotometer, power supply, and portable laboratory in a canoe.
- 2) By increasing the frequency and season of sampling the relationship between concentrations of trace elements in water and sediments will be better understood. The correlation between water and sediment chemistry will undoubtedly serve as an important data base for vegetation and faunal studies.
- 3) With reference to trace metals in sediments, the river below Rush contains anomalously high concentrations of Zn and Cd. The sediments from the area around and below Rush will be examined in detail during the FY 74 program to better assess potential problems related to water use and water quality in the fishery near Rush.
- 4) At the request of the National Park Service, the faunal study has been given a relatively low priority on the overall long term program. However, the relatively low benthic productivity as indicated in this preliminary study would suggest an immediate need for future study. Certainly the location of proposed fisheries should be based on benthic faunal productivity data. Such a benthic faunal study should be included in the FY 74 program.
- 5) The measurement of herbicides and pesticides should be included in the FY 74 program.

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APPENDICES

(Prepared by Paul D. Kittle)

Appendix A

BR-1 23 May 1973 Qualitative Samples

ISOPODA

Asellidae

Lirceus sp. 1

DECAPODA

Astacidae

Orconectes sp. male 1

EPHEMEROPTERA

Baetidae

Baetis sp. 1Pseudocloeon sp. 27

Heptageniidae

Heptagenia sp. 12Stenonema sp. 5

Leptophlebiidae

Paraleptophlebia sp. 13

Ephemerellidae

Ephemerella sp. 2

PLECOPTERA

Perlidae

Perlesta sp. 1

Perlodidae

Isoperla sp. 5

Chloroperlidae

Hastaperla sp. 1

COLEOPTERA

Psephenidae

Psephenus sp.

larva 1

TRICHOPTERA

unidentified pupa 4

Appendix A--continued

BR-2 23 May 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 2

Baetidae

Baetis sp. 1Pseudocloeon sp. 43

Heptageniidae

Epeorus ? sp. adult 2Stenonema sp. 28

Ephemerellidae

Ephemerella sp. 1~~Caenidae~~Caenis sp. 1

PLECOPTERA

Perlidae

Perlesta sp. 9

Perlodidae

unidentified adult 1

COLEOPTERA

Psephenidae

Ectopria sp. (larva) 1Psephenus sp. (larva) 1

TRICHOPTERA

unidentified pupa 1

Hydropsychidae

Cheumatopsyche sp. 2

Helicopsychidae

Helicopsyche sp. 1

DIPTERA

Chironomidae 9

Simuliidae 3

GASTROPODA 36

Appendix A--continued

BR-3 23 May 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 2

unidentified female 3

DIPTERA

Tipulidae ? 1

GASTROPODA 15

EPHEMEROPTERA

Baetidae

Pseudocloeon sp. 28

Heptageniidae

Heptagenia sp. 12Stenonema sp. 12

Leptophlebiidae

Paraleptophlebia sp. 6

Ephemerellidae

Ephemerella sp. 13

Potamanthidae

Potamanthus sp. 3

PLECOPTERA

Perlidae

Perlesta sp. 2

Perlodidae

Isoperla sp. 2

COLEOPTERA

Psephenidae

Psephenus sp. (larva) 1

TRICHOPTERA

unidentified pupa 1

Philopotamidae

Chimarra sp. (adult at light)

Hydropsychidae

unidentified adults at lights 6

Cheumatopsyche sp. 4

Helicopsychidae

Helicopsyche sp. 1

Appendix A--continued

BR-4 23 May 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 1

unidentified female 1

unidentified juvenile 1

EPHEMEROPTERA

Baetidae

Baetis sp. 3Pseudocloeon sp. 2

Heptageniidae

Heptagenia sp. 3Rhithrogena sp. 4Stenonema sp. 57

Leptophlebiidae

Paraleptophlebia sp. 1

Ephemerellidae

Ephemerella sp. 2

ODONATA

Coenagrionidae

Argia sp. (nymph) 1

PLECOPTERA

Perlidae

Perlesta sp. 2

COLEOPTERA

Elmidae

Promoresia ? sp. (adult) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 3

GASTROPODA 1

PELECYPODA 2

Appendix A--continued

BR-5 22 May 1973 Qualitative Samples

DECAPODA

Astacidae

unidentified juvenile 1

EPHEMEROPTERA

Heptageniidae

Heptagenia sp. 1Stenonema sp. 2

Caenidae

Caenis sp. 2

Appendix A--continued

BR-6 22 May 1973 Qualitative Samples

OLIGOCHAETA

Lumbriculidae ? 1

EPHEMEROPTERA

Heptageniidae

Heptagenia sp. 1Rhithrogena sp. 8Stenonema sp. 35

Potamanthidae

Potamanthus sp. 1

ODONATA

Coenagrionidae

Argia sp. (nymph) 1

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. 3

COLEOPTERA

Dryopidae

Helichus sp. (adult) 2

Elmidae

Stenelmis sp. (adult) 4

TRICHOPTERA

unidentified pupa 1

DIPTERA

Simuliidae 1

GASTROPODA 30

Appendix A--continued

BR-7 22 May 1973 Qualitative Samples

DECAPODA

Astacidae

unidentified female 1

EPHEMEROPTERA

Heptageniidae

Stenonema sp. 7

Leptophlebiidae

Paraleptophlebia sp. 1

PLECOPTERA

Perlidae

Neoperla sp. 1Perlesta sp. 3

COLEOPTERA

Hydrophilidae

Cymbiodyta sp. (adult) 1

Dryopidae

Helichus sp. (adult) 1

Psephenidae

Ectopria sp. (larva) 1Psephenus sp. (larva) 1

Elmidae

Stenelmis sp. (adult) 1

GASTROPODA 4

Appendix A--continued

BR-8 22 May 1973 Qualitative Samples

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Heptageniidae

Heptagenia sp. 1Rhithrogena sp. 4Stenonema sp. 17

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. 8

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 4

DIPTERA

Chironomidae 2

GASTROPODA 157

Appendix B

BR-1 15 June 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 3

unidentified female 4

EPHEMEROPTERA

Baetidae

Baetis sp. 2Pseudocloeon sp. 23

Heptageniidae

Heptagenia sp. 9

Leptophlebiidae

Paraleptophlebia sp. 3

ODONATA

Coenagrionidae

unidentified adult 1

PLECOPTERA

Perlidae

Perlesta sp. 2

COLEOPTERA

Psephenidae

Psephenus sp. (larva) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 9

DIPTERA

Chironomidae 13

Simuliidae 5

Appendix B--continued

BR-2 15 June 1973 Qualitative Samples

EPHEMEROPTERA

Baetidae

Baetis sp. 1Pseudocloeon sp. 31

Heptageniidae

Heptagenia sp. 1Stenonema sp. 3

ODONATA

Coenagrionidae

Argia sp. (adult) 1

PLECOPTERA

Perlidae

Perlesta sp. 3

COLEOPTERA

Limnichidae

Lutrochus sp. 9

Psephenidae

Psephenus sp. (larva) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 4

DIPTERA

Tipulidae 1

Chironomidae 5

Simuliidae 8

Appendix B--continued

BR-3 15 June 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 2

unidentified female 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Baetidae

Pseudocloeon sp. 2

Heptageniidae

Heptagenia sp. 7Stenonema sp. 5

Leptophlebiidae

Choroterpes sp. 2

Ephemerellidae

Ephemerella sp. 2

Potamanthidae

Potamanthus sp. 1

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. 7

COLEOPTERA

Psephenidae

Psephenus sp. (larva) 2

Elmidae

Stenelmis sp. (adult) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 12

DIPTERA

Chironomidae 3

GASTROPODA 1

Appendix B--continued

BR-4 15 June 1973 Qualitative Samples

DECAPODA

Astacidae
 unidentified female 1

EPHEMEROPTERA

Siphonuridae
 Isonychia sp. 2

Baetidae
 Baetis sp. 2
 Pseudocloeon sp. 2

Heptageniidae
 Heptagenia sp. 3
 Stenonema sp. 6

PLECOPTERA

Nemouridae
 Brachyptera ? sp. 1

Perlidae
 Perlesta sp. 3

COLEOPTERA

Psephenidae
 Psephenus sp. (adult) 2

NEUROPTERA

Corydalidae
 Corydalus sp. 2

TRICHOPTERA

Philopotamidae
 Chimarra sp. 1

Psychomyiidae
 Cyrnellus ? sp. 1

Hydropsychidae
 Cheumatopsyche sp. 8

DIPTERA

Chironomidae 7

Simuliidae 1

Appendix B--continued

BR-5 14 June 1973 Qualitative Samples

HIRUDINEA 1

DIPTERA

ISOPODA

Simuliidae 1

Asellidae

GASTROPODA 36

Asellus sp. 1

EPHEMEROPTERA

Baetidae

Baetis sp. 2

Heptageniidae

Heptagenia sp. 2Rhithrogena sp. 1Stenonema sp. 4

ODONATA

Coenagrionidae

Argia sp. (nymph) 1Argia sp. (adult) 2

PLECOPTERA

Perlidae

Perlesta sp. (nymph) 10
adult 1

COLEOPTERA

Limnichidae

Lutrochus sp. (adult) 5

Psephenidae

Psephenus sp. (adult) 1

Elmidae

Stenelmis sp. (adult) 1

NEUROPTERA

Corydalidae

Corydalus sp. 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 1

Appendix B--continued

BR-6 14 June 1973 Qualitative Samples

OLIGOCHAETA

Lumbriculidae ? 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Baetidae

Baetis sp. 2

Heptageniidae

Heptagenia sp. 4Stenonema sp. 17

Ephemerellidae

Ephemerella sp. 2

Tricorythidae

Tricorythodes sp. 1

PLECOPTERA

Perlidae

Perlesta sp. 1

COLEOPTERA

Dryopidae

Helichus sp. (adult) 3

Psephenidae

Psephenus sp. (larva) 1

Elmidae

Stenelmis sp. (adult) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 1

DIPTERA

Chironomidae 3

GASTROPODA 8

Appendix B--continued

BR-7

14 June 1973

Qualitative Samples

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 2

Heptageniidae

Heptagenia sp. 3Stenonema sp. 15

Tricorythidae

Tricorythodes sp. 1

PLECOPTERA

Perlidae

Neoperla sp. 1Perlesta sp. (nymph) 6
(adult) 1

COLEOPTERA

Dytiscidae

Hydrovatus sp. (adult) 1

Hydrophilidae

Berosus sp. (adult) 1Enochrus sp. (adult) 2

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 1

GASTROPODA 1

Appendix B--continued

BR-8 14 June 1973 Qualitative Samples

DECAPODA

Astacidae

unidentified female 1

unidentified juvenile 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 2

Baetidae

Pseudocloeon sp. 7

Heptageniidae

Heptagenia sp. 5Stenonema sp. 20

Leptophlebiidae

Paraleptophlebia sp. 1

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. 4

COLEOPTERA

Limnichidae

Lutrochus sp. (adult) 1

Psephenidae

Psephenus sp. (larva) 1

Elmidae

Stenelmis sp. (adult) 1

NEUROPTERA

Corydalidae

Corydalus sp. 2

TRICHOPTERA

unidentified pupa 1

TRICHOPTERA (continued)

Philopotamidae

Chimarra sp. 1

Hydropsychidae

Cheumatopsyche sp. 7

DIPTERA

Chironomidae 4

Simuliidae 1

GASTROPODA 20

PELECYPODA 1

Appendix C

BR-1 25 June 1973 Qualitative Samples

OLIGOCHAETA

Lumbriculidae ? 1

DECAPODA

Astacidae

Orconectes sp. male 2

unidentified female 3

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 7

Baetidae

Baetis sp. 5Pseudocloeon sp. 23

Heptageniidae

Heptagenia sp. 7Stenonema sp. 1

Leptophlebiidae

Habrophlebiodes sp. 1

PLECOPTERA

Perlidae

Perlesta sp. (nymph) 3
(adult) 4

COLEOPTERA

Psephenidae

Psephenus sp. (larva) 1
(adult) 4

Elmidae

unidentified larva 1

NEUROPTERA

Corydalidae

Corydalis sp. 1

TRICHOPTERA

Hydropsychidae

Chematopsyche sp. 15

DIPTERA

Tipulidae ? 1

Chironomidae 9

GASTROPODA 1

Appendix C---continued

BR-2 25 June 1973

Qualitative Samples

OLIGOCHAETA

Lumbriculidae ? 5

DECAPODA

Astacidae

Orconectes sp. male 3

unidentified female 5

unidentified juvenile 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 52

Baetidae

Baetis sp. 7Pseudocloeon sp. 1

Heptageniidae

Heptagenia sp. 4Stenonema sp. 22

Leptophlebiidae

Choroterpes sp. 1

ODONATA

Calopterygidae

Hetaerina sp. (adult) 1

Coenagrionidae

Unidentified adult

Argia sp. (adult) 2

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. (nymph) 11
(adult) 4

COLEOPTERA

Gyrinidae

Dineutus sp. (adult) 6

Limnichidae

Lutrochus sp. (adult) 1

Psephenidae

Psephenus sp. (larva) 1
(adult) 2

Elmidae

unidentified larva 1

Stenelmis sp. (adult) 2

NEUROPTERA

Corydalidae

Corydalis sp. 5

TRICHOPTERA

unidentified pupa 1

Philopotamidae

Chimarra sp. 1

Hydropsychidae

Cheumatopsyche sp. 21Hydropsyche sp. 2

DIPTERA

Chironomidae 5

Simuliidae 1

GASTROPODA

Appendix C--continued

BR-4

24 June 1973

Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 2

unidentified female 2

unidentified juvenile 3

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 25

Heptageniidae

Heptagenia sp. 4Rithrogena sp. 1Stenonema sp. 26

Leptophlebiidae

Choroterpes sp. 4

Tricorythidae

Tricorythodes sp. 2

Caenidae

Caenis sp. 2

PLECOPTERA

Perlidae

Acroneuria sp. 2Neoperla sp. 1Perlesta sp. 2

COLEOPTERA

Limnichidae

Lutrochus sp. (adult) 2

Psephenidae

Psephenus sp. (adult) 1

Elmidae

unidentified larva 1

Stenelmis sp. (adult) 1

NEUROPTERA

Corydalidae

Corydalus sp. 6

TRICHOPTERA

Philopotamidae

Chimarra sp. 1

Psychomyiidae

Cyrnellus ? sp. 2

Hydropsychidae

Cheumatopsyche sp. 14

DIPTERA

Chironomidae 6

Appendix C--continued

BR-5 24 June 1973 Qualitative Samples

DECAPODA

Astacidae

Orconectes sp. male 2

unidentified female 1

EPHEMEROPTERA

Baetidae

Pseudocloeon sp. 2

Heptageniidae

Stenonema sp. 11

Caenidae

Caenis sp. 1

ODONATA

Coenagrionidae

Argia sp. (adult) 9

PLECOPTERA

Perlidae

Perlesta sp. (numph) 5
(adult) 21

COLEOPTERA

Limnichidae

Lutrochus sp. (adult) 1

NEUROPTERA

Corydalidae

Corydalus sp. 3

GASTROPONDA 20

PELECYPODA 6

Appendix C--continued

BR-6

24 June 1973

Qualitative Samples

DECAPODA

Astacidae

unidentified juvenile 2

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 2

Heptageniidae

Heptagenia sp. 1Stenonema sp. 16

Potamanthidae

Potamanthus sp. 1

Polymitarcidae

Ephoron sp. 2

COLEOPTERA

Hydrophilidae

Cymbiodyta sp. (adult) 2

Limmichidae

Lutrochus sp. (adult) 2

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 2Hydropsyche sp. 2

DIPTERA

Chironomidae (larve) 8

(pupa) 3

GASTROPODA 11

Appendix C--continued

BR-7

24 June 1973

Qualitative Samples

EPHEMEROPTERA

Baetidae

Baetis sp. 1

Heptageniidae

Heptagenia sp. 1Stenonema sp. 7

Leptophlebiidae

Choroterpes sp. 2

Tricorythidae

Tricorythodes sp. 1

Potamanthidae

Potamanthus sp. 1

PLECOPTERA

Perlidae

Perlesta sp. (adult) 1

COLEOPTERA

Gyrinidae

Dineutus sp. (adult) 7

Hydrophilidae

Berosus sp. (adult) 2

Elmidae

unidentified larva 1

Stenelmis sp. (adult) 2

NEUROPTERA

Corydalidae

Chauliodes sp. 1

TRICHOPTERA

Hydropsychidae

Hydropsyche sp. 1

DIPTERA

Chironomidae 5

Simuliidae 1

GASTROPODA 4

Appendix C--continued

BR-8

24 June 1973

Qualitative Samples

DECAPODA

Astacidae
unidentified female 2

EPHEMEROPTERA

Siphonuridae
Isonychia sp. 10

Baetidae
Pseudocloeon sp. 3

Heptageniidae
Heptagenia sp. 3
Stenonema sp. 35

Polymitarcidae
Ephoron sp. 2

ODONATA

Coenagrionidae
Argia sp. (adult) 1

PLECOPTERA

Perlidae
Neoperla sp. 1
Perlesta sp. (nymph) 10
(adult) 1

COLEOPTERA

Hydrophilidae
Berosus sp. (adult) 6

Limnichidae
Lutrochus sp. (adult) 6

Psephenidae
Psephenus sp. (larva) 2

Elmidae
Stenelmis sp. (adult) 4

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 15
Hydropsyche sp. 1

DIPTERA

Chironomidae (larva) 14
(pupa) 2

Simuliidae 5

GASTROPODA 27

PELECYPODA 1

Appendix D

BR-1 15 June 1973 Quantitative Sample 6 ft²

ISOPODA

Asellidae

Asellus sp. 2

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Baetidae

Baetis sp. 1

Pseudocloeon sp. 4

Heptageniidae

Heptagenia sp. 4

Stenonema sp. 1

Leptophlebiidae

Habrophlebiodes sp. 1

Paraleptophlebia sp. 3

Caenidae

Caenis sp. 2

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 1

DIPTERA

Chironomidae 1

SUMMARY

ISOPODA 2

EPHEMEROPTERA 17

TRICHOPTERA 1

DIPTERA 1

TOTAL ORGANISMS 21

Appendix D--continued

BR-2 15 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Baetidae

Pseudocloeon sp. 8

Heptageniidae

Stenonema sp. 1

Tricorythidae

Tricorythodes sp. 1

PLECOPTERA

Perlidae

Perlesta sp. 1

DIPTERA

Chironomidae (larva) 1
 (pupa) 1

SUMMARY

EPHEMEROPTERA 10

PLECOPTERA 1

DIPTERA 2

TOTAL ORGANISMS 13

Appendix D--continued

BR-3 15 June 1973 Quantitative Sample 6 ft²

DECAPODA

Astacidae

Orconectes sp. male 3

unidentified female 1

unidentified juvenile 1

EPHEMEROPTERA

Baetidae

Baetis sp. 1

Pseudocloeon sp. 4

Heptageniidae

Heptagenia sp. 10

Stenonema sp. 11

Tricorythidae

Tricorythodes sp. 1

COLEOPTERA

Psephenidae

Psephenus sp. (larva) 1

DIPTERA

Chironomidae 6

SUMMARY

DECAPODA 5

EPHEMEROPTERA 27

COLEOPTERA 1

DIPTERA 6

TOTAL ORGANISMS 39

Appendix D--continued

BR-4 15 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

SUMMARY

Siphonuridae
Isonychia sp. 4

EPHEMEROPTERA 27

PLECOPTERA 4

Baetidae
Baetis sp. 1
Pseudocloeon sp. 7

COLEOPTERA 1

TRICHOPTERA 3

Heptageniidae
Heptagenia sp. 5
Stenonema sp. 7

DIPTERA 5

TOTAL ORGANISMS 40

Leptophlebiidae
Habrophlebiodes sp. 2

Ephemerellidae
Ephemerella sp. 1

PLECOPTERA

Perlidae
Perlesta sp. 4

COLEOPTERA

Limnichidae
Lutrochus sp. 1

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 3

DIPTERA

Chironomidae (larva) 3

Simuliidae 1

Appendix D--continued

BR-5 14 June 1973 Quantitative Sample 6 ft²

PLECOPTERA

Perlidae

Neoperla sp. 1 Perlesta sp. 1

GASTROPODA 3

PELECYPODA 1

SUMMARY

PLECOPTERA 2

GASTROPODA 3

PELECYPODA 1

TOTAL ORGANISMS 6

Appendix D--continued

BR-6 14 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Baetidae

Pseudocloeon sp. 1

Heptageniidae

Heptagenia sp. 2

Stenonema sp. 1

COLEOPTERA

Hydrophilidae

Berosus sp. (adult) 1

GASTROPODA 1

SUMMARY

EPHEMEROPTERA 4

COLEOPTERA 1

GASTROPODA 1

TOTAL ORGANISMS 6

Appendix D--continued

BR-7 14 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Heptageniidae

Heptagenia sp. 5

Stenonema sp. 2

Caenidae

Caenis sp. 1

Polymitarcidae

Ephoron sp. 3

PLECOPTERA

Perlidae

Perlesta sp. 1

COLEOPTERA

Elmidae

Stenelmis sp. (adult) 2

NEUROPTERA

Corydalidae

Corydalus sp. 1

DIPTERA

Chironomidae 1

GASTROPODA 1

SUMMARY

EPHEMEROPTERA 11

PLECOPTERA 1

COLEOPTERA 2

NEUROPTERA 1

DIPTERA 1

GASTROPODA 1

TOTAL ORGANISMS 17

Appendix D--continued

BR-8 14 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Heptageniidae

Heptagenia sp. 2

Stenonema sp. 14

Tricorythidae

Tricorythodes sp. 2

ODONATA

Gomphidae 1

PLECOPTERA

Perlidae

Neoperla sp. 1

Perlesta sp. 5

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 1

DIPTERA

Chironomidae 3

SUMMARY

EPHEMEROPTERA 19

ODONATA 1

PLECOPTERA 6

TRICHOPTERA 1

DIPTERA 3

GASTROPODA 1

TOTAL ORGANISMS 31

Appendix E

BR-1 25 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Baetidae

Baetis sp. 5

Pseudocloeon sp. 11

Heptageniidae

Heptagenia sp. 4

Rhithrogena sp. 1

Stenonema sp. 5

Leptophlebiidae

Habrophlebiodes sp. 1

Caenidae

Caenis sp. 2

TRICHOPTERA

unidentified pupa 1

Psychomyiidae

Cyrnellus ? sp. 1

Hydropsychidae

Cheumatopsyche sp. 4

DIPTERA

Chironomidae (larva) 2
 (pupa) 1

Simuliidae 1

SUMMARY

EPHEMEROPTERA 29

TRICHOPTERA 6

DIPTERA 4

TOTAL ORGANISMS 39

Appendix E-continued

BR-2 25 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

GASTROPODA 1

Siphonuridae

SUMMARYIsonychia sp. 2

EPHEMEROPTERA 21

Baetidae

PLECOPTERA 3

Baetis sp. 2Pseudocloeon sp. 4

COLEOPTERA 7

Heptageniidae

NEUROPTERA 1

Heptagenia sp. 2Stenonema sp. 8

TRICHOPTERA 5

Caenidae

DIPTERA 12

Caenis sp. 3

PLECOPTERA

GASTROPODA 1

Perlidae

TOTAL ORGANISMS 50

Perlesta sp. 3

COLEOPTERA

Limnichidae

Lutrochus sp. (adult) 5

Psephenidae

Psephenus sp. (adult) 1

Elmidae

Stenelmis sp. (adult) 1

NEUROPTERA

Corydalidae

Corydalis sp. 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 4Hydropsyche sp. 1

DIPTERA

unidentified pupa 2

Chironmidae 6

Simuliidae 4

Appendix E-continued

BR-3 25 June 1973 Quantitative Sample 6 ft²

DECAPODA

Astacidae

Orconectes sp. male 1

unidentified juvenile 1

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 2

Baetidae

Baetis sp. 18

Pseudocloeon sp. 3

Heptageniidae

Heptagenia sp. 1

Stenonema sp. 9

Tricorythidae

Tricorythodes sp. 7

PLECOPTERA

Perlidae

Perlesta sp. 1

TRICHOPTERA

Philopotamidae

Chimarra sp. 1

Hydropsychidae

Cheumatopsyche sp. 18

Hydropsyche sp. 1

DIPTERA

Tipulidae ? 1

Chironomidae (larva) 6
(pupa) 2

GASTROPODA 5

SUMMARY

DECAPODA 2

EPHEMEROPTERA 42

PLECOPTERA 1

TRICHOPTERA 20

DIPTERA 9

GASTROPODA 5

TOTAL ORGANISMS 79

Appendix E--continued

BR-4 24 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

SUMMARYSiphonuridae
Isonychia sp. 2

EPHEMEROPTERA 10

Baetidae
Baetis sp. 1
Pseudocloeon sp. 1

PLECOPTERA 3

Heptageniidae
Rhithrogena sp. 1
Stenonema sp. 5

COLEOPTERA 12

NEUROPTERA 2

TRICHOPTERA 4

DIPTERA 5

PLECOPTERA

TOTAL ORGANISMS 36

Perlidae
Neoperla sp. 1
Perlesta sp. 2

COLEOPTERA

Limnichidae
Lutrochus sp.Psephenidae
Psephenus sp. (adult) 9Elmidae
Stenelmis sp. (adult) 1

NEUROPTERA

Corydalidae
Corydalus sp. 2

TRICHOPTERA

Psychomyiidae
Cyrnellus ? sp. 1Hydropsychidae
Cheumatopsyche sp. 3

DIPTERA

Simuliidae 5

Appendix E--continued

BR-5 24 June 1973 Quantitative Sample 6 ft²

OLIGOCHAETA

Lumbriculidae ? 3

DIPTERA

Chrionomidae (larva) 4
(pupa) 1

ISOPODA

Asellidae

Asellus sp. 1

Simuliidae 4

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

GASTROPODA 4

PELECYPODA 2

Baetidae

Baetis sp. 6Centroptilum sp. 1Pseudocloeon sp. 3SUMMARY

OLIGOCHAETA 3

ISOPODA 1

EPHEMEROPTERA 19

Heptageniidae

Heptagenia sp. 1Stenonema sp. 4

PLECOPTERA 6

COLEOPTERA 2

Polymitarcidae

Ephoron sp. 3

TRICHOPTERA 4

DIPTERA 9

PLECOPTERA

Perlidae

Acroneuria sp. 1Perlesta sp. 5

GASTROPODA 4

PELECYPODA 2

TOTAL ORGANISMS 50

COLEOPTERA

Dryopidae

Helichus sp. 1

Elmidae

unidentified larva 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 2Hydropsyche sp. 2

Appendix E--continued

BR-6 24 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Siphonuridae

Isonychia sp. 1

Heptageniidae

Rhithrogena sp. 1

Stenonema sp. 8

Polymitarcidae

Ephoron sp. 4

COLEOPTERA

Elmidae

Stenelmis sp. (adult) 1

TRICHOPTERA

Hydropsychidae

Cheumatopsyche sp. 3

DIPTERA

Chironomidae (larva) 1

SUMMARY

EPHEMEROPTERA 14

COLEOPTERA 1

TRICHOPTERA 3

DIPTERA 1

TOTAL ORGANISMS 19

Appendix E--continued

BR-7 24 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

Heptageniidae

Stenonema sp. 1

Tricorythidae

Tricorythodes sp. 1

Caenidae

Brachycercus sp. 1

Polymitarcidae

Ephoron sp. 3

NEUROPTERA

Corydalidae

Chauliodes sp. 1

DIPTERA

Chironomidae (larva) 1
 (pupa) 1

GASTROPODA 2

SUMMARY

EPHEMEROPTERA 6

NEUROPTERA 1

DIPTERA 2

GASTROPODA 2

TOTAL ORGANISMS 11

Appendix E--continued

BR-8 24 June 1973 Quantitative Sample 6 ft²

EPHEMEROPTERA

SUMMARYSiphonuridae
Isonychia sp. 2

EPHEMEROPTERA 43

Baetidae
Baetis sp. 1

PLECOPTERA 5

Heptageniidae
Stenonema sp. 17

COLEOPTERA 3

Caenidae
Caenis sp. 1

TRICHOPTERA 8

Polymitarcidae
Ephoron sp. 22

DIPTERA 6

GASTROPODA 3

TOTAL ORGANISMS 68

PLECOPTERA

Perlidae
Perlesta sp. 5

COLEOPTERA

Elmidae
Stenelmis sp. (adult) 3

TRICHOPTERA

Hydropsychidae
Cheumatopsyche sp. 7
Hydropsyche sp. 1

DIPTERA

Tipulidae 1

Chironomidae (larva) 3

Simuliidae 2

GASTROPODA 3

